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A revision of Antarctic and some Indo-Pacific apodid sea cucumbers (Echinodermata: Holothuroidea: Apodida)

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Abstract

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Eight new apodid species from Antarctica are described: myriotrochids *Achiridota smirnovi* sp. nov., *Myriotrochus nikiae* sp. nov., *Prototrochus linseae* sp. nov., *Prototrochus barnesi* sp. nov., and chiridotids *Kolostoneura griffithsi* sp. nov., *Scoliorhapis bipearli* sp. nov., *Scoliorhapis massini* sp. nov., *Taeniogyrus prydzi* sp. nov. Genera *Scoliorhapis* H. L. Clark, *Taeniogyrus* Semper and *Trochodota* Ludwig are reviewed. *Scoliodotella* Oguro is a junior synonym of *Scoliorhapis* H. L. Clark. *Trochodota* Ludwig type species is fixed as *Holothuria (Fistularia) purpurea* Lesson. *Trochodota* Ludwig is a junior synonym of *Taeniogyrus* Semper. *Sigmodota* Studer type species is fixed as *Chiridota contorta* Ludwig, and *Sigmodota* Studer is raised out of synonymy with *Taeniogyrus* Semper. Species assigned to *Sigmodota* are *Chiridota contorta* Ludwig, *Taeniogyrus dubius* H. L. Clark (as *Sigmodota dubia*) and *Taeniogyrus magnibaculus* Massin and Hétérier (as *Sigmodota magnibacula*). Non-Antarctic new genus *Rowedota* gen. nov. is erected with type species *Taeniogyrus allani* Joshua, and other assigned species *Trochodota epiphyka* O'Loughlin, *Trochodota mira* Cherbonnier, *Trochodota shepherdi* Rowe and *Trochodota vivipara* Cherbonnier. *Trochodota* species not assigned to *Rowedota* gen. nov. and *Sigmodota* Studer are assigned to *Taeniogyrus* Semper. Other Antarctic apodid species discussed are *Myriotrochus antarcticus* Smirnov and Bardsley, *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza and *Taeniogyrus antarcticus* Heding. Non-Antarctic apodid species discussed are *Chiridota pisanii* Ludwig, *Chiridota australiana* Stimpson and *Trochodota maculata* H. L. Clark. The spelling of the species name *Myriotrochus macquariensis* Belyaev and Mironov is corrected. A table with Antarctic Apodida species and their distributions is provided. A table with specimen and ossicle sizes for some Taeniogyrinae species is provided. A key to genera of Taeniogyrinae is provided. Species names are standardized to: *macquariensis*; *studeri*; *theeli*.

Keywords

Achiridota, *Chiridota*, *Kolostoneura*, *Myriotrochus*, *Paradota*, *Prototroch*us, *Scoliorhapis*, *Scoliodotella*, *Sigmodota*, *Taeniogyrus*, *Trochodota*, emended diagnoses, new genus, new species, Antarctic, Bellingshausen Sea, Indo–Pacific, Prydz Bay, Ross Sea, Scotia Sea, Weddell Sea.

Introduction

This review of Antarctic apodid genera and species has become possible with the opportunities to study numbers of Antarctic holothuroid collections (Table 1).

ANARE 1993 collected with a Van Veen grab and epibenthic sled, and recent BIOPEARL expeditions used an epibenthic sled, and both yielded many very small specimens including the apodids that are reported in this study. Tissue samples from recent NIWA and US AMLR and BAS collections are currently being processed for molecular sequences, but this systematic study is based exclusively on morphological characters and the species recognized as morpho-species.

Numerous systematic problems have arisen during the study of species of Taeniogyrinae Smirnov, 1998. There has been a significant history of misidentifications of Antarctic and Magellanic species. A succession of authors has been dissatisfied with the systematic status of one or both of the genera *Taeniogyrus* Semper, 1867 and *Trochodota* Ludwig, 1891, including Dendy (1909), Joshua (1914), H. L. Clark (1921), Rowe (1976), Rowe (in Rowe and Gates 1995), Smirnov (1997), Massin and Hétérier (2004) and O'Loughlin and VandenSpiegel (2007). The presence or absence of clusters of wheels in the body wall is the generic diagnostic distinction between *Taeniogyrus* and *Trochodota* species, and has proved to be subjective and unsatisfactory. And a useful generic diagnostic character for taeniogyrinid species, namely the arrangement of teeth on the inner rim of the wheel ossicles, became potentially lost because of a misunderstanding in a revision of a type species. We attempt to improve systematic clarity around these issues.

Table 1. Antarctic collections studied.

Names of expeditions	Localities	Specimens lodged
Terra Nova 1910–1913	Ross Sea	Natural History Museum (London)
Discovery Expedition	South Atlantic, Scotia Sea	Natural History Museum (London)
BANZARE	Eastern Antarctica, Kerguelen Islands	South Australian Museum
US Antarctic Research Program	Antarctic Ocean	US National Museum of Natural History (Smithsonian Institution)
ANARE	Prydz Bay, Heard Island	Museum Victoria, Tasmanian Museum, South Australian Museum
Tangaroa Ross Sea	Ross Sea	New Zealand Institute of Water and Atmospheric Research
Hesperides BENTART–2003, BENTART–2006	Amundsen Sea, Bellingshausen Sea	University of Malaga
British Antarctic Survey BIOPEARL 2006, BIOPEARL 2008	Bellingshausen Sea, Scotia Sea	Natural History Museum (London), Museum Victoria
US Antarctic Marine Living Resources 2004, 2005, 2009	South Atlantic, Scotia Sea	Museum Victoria
US Antarctic Marine Living Resources 2006	Antarctic Peninsula	US National Museum of Natural History (Smithsonian Institution)

Methods

Photographs of preserved specimens (Figure 1) were taken using a Pentax K–7 camera with Olympus 38 mm macro lens on bellows. Photographs were taken at f11–f16 using twin flashes. The photograph of a preserved specimen of *Myriotrochus antarcticus* was taken using a Leica MZ12.5 compound microscope, Q imaging camera, and Auto-Montage software. The photograph of a preserved specimen of *Taeniogyrus australianus* was taken using a SLR Canon EOS5D digital camera with 65 mm lens. For scanning electron microscope (SEM) observations ossicles were cleared of associated soft tissues in commercial bleach, air-dried, mounted on aluminium stubs, and coated with gold. Observations were made using a JEOL JSM–6480LV SEM. Measurements were made with Smile view software. Montage photographs of ossicles were taken using a Leica CTR5000 compound microscope, Leica DC500 digital camera, and Auto-Montage software. Drawings were done by Mark O'Loughlin.

Corrected taxa spellings

Myriotrochus macquariensis Belyaev and Mironov, 1981 was named for material collected near Macquarie Island, and the original spelling of the species name as *macquoriensis* was a *lapsus calami*. We correct the "incorrect original spelling" to *macquariensis* in accord with Article 32.5 of the ICZN (1999).

Ludwig (1875) and some subsequent authors used the generic name *Chirodota* instead of *Chiridota* Eschscholtz, 1829. The correct spelling *Chiridota* is used throughout this paper.

Théel (1886a) erected the species *Chiridota studerii*. The species name has various spellings in the literature and we use the appropriate spelling *studeri* throughout this work.

Heding (1928) erected the species *Scoliodota theelii*. We use the appropriate spelling *theeli* throughout this work.

Abbreviations

AM	Australian Museum (echinoderm registration numbers with prefix J).
AMLR	Antarctic Marine Living Resources.
ANARE	Australian National Antarctic Research Expedition.
BANZARE	British, Australian, New Zealand Antarctic Research Expedition.
BAS	British Antarctic Survey.
BIOROSS–NIWA	*Tangaroa* 2004 expedition to the Ross Sea.
ICZN	International Code of Zoological Nomenclature (1999).
MNA	University of Genoa registration number prefix for BIOROSS *Tangaroa* 2004 and other Ross Sea holothuroid specimens.
NHM	British Museum of Natural History.
NIWA	New Zealand Institute of Water and Atmospheric Research.
NMNH	National Museum of Natural History, Smithsonian Institution.

NMV	Museum Victoria (echinoderm registration numbers with prefix F).
NZ IPY–CAML	New Zealand International Polar Year–Census of Antarctic Marine Life Project cruise TAN0802.
RBINS	Royal Belgian Institute of Natural Sciences. All SEM material observed during this study is deposited in RBINS.
SAM	South Australia Museum.
TMAG	Tasmania Museum and Art Gallery.
USARP	United States Antarctic Research Progam.
USNM	United States National Museum. Historically three types of registration have been used for USNM specimens: Echinoderm catalogue numbers prior to 1920 did not have a prefix, subsequently had the prefix E, and since 2001 the EMU on-line system has been used and registrations reported as USNM without an E prefix.

Numbers in brackets after registrations refer to numbers of specimens in lots.

In this work Antarctic refers to the region south of the Polar Front/Antarctic Convergence.

Relevant history of species misidentification

Three chiridotid species occur in the Magellanic/Falklands region (north of the Polar Front/Antarctic Convergence): *Chiridota pisanii* Ludwig, 1886 (12 tentacles, wheels in papillae in body wall, lacking hooks); *Chiridota contorta* Ludwig, 1875 (12 tentacles, wheels in discrete clusters / papillae in the body wall, and hooks); *Holothuria (Fistularia) purpurea* Lesson, 1830 (10 tentacles, wheels not in clusters in body wall, and hooks). *Taeniogyrus antarcticus* Heding, 1931 (10 tentacles, wheels in some groups, and hooks in body wall) has been found only south of the Polar Front at South Georgia, Shag Rocks and the S Orkney Is (see below), but not in the Falklands/Magellanic region.

Lampert (1885, 1886) discussed *Chiridota purpurea* (Lesson), and provided complete synonymies. Subsequently Lampert (1889) recognized that the material that he had described was *Chiridota contorta* Ludwig, and retained only Bell (1881) in his synonymy for *Chiridota purpurea* (Lesson).

Studer (1876) erected a new genus *Sigmodota* because of the presence of sigmoid hooks in an apodid species from both the Kerguelen Is and Magellanic region. He reported 12 tentacles, ignored the original description of 10 tentacles by Lesson (1830), and referred *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 to his *Sigmodota*. Théel (1886a, page 16) thought that it was "very peculiar" that no *Challenger* specimen from the Kerguelen Is and Strait of Magellan had 12 tentacles and hooks but no wheels. All *Challenger* specimens had aggregations of wheels, and Théel wondered if "the very scattered aggregations of wheels had escaped the attention of Studer". After more than another century of collecting in these two regions still no specimen with 12 tentacles and hooks but lacking wheels has been found. We agree with Théel's concern (1886a, page 16) and judge that Studer did not notice the presence of wheels in his material since the only Chiridotidae species that has been found in the Kerguelen Is (see O'Loughlin 2009) and also in the Magellanic region (this work) is *Chiridota contorta* Ludwig (with 12 tentacles, hooks and wheels). We agree with Ludwig's (1898) judgment that Studer's *Sigmodota purpurea* (Lesson, 1830) is a junior synonym of *Chiridota contorta* Ludwig.

Théel (1886a) judged that the material referred by Studer (1876) to *Sigmodota purpurea* (Lesson) was not *Holothuria* (*Fistularia*) *purpurea* Lesson, presumably because of an absence of wheels. He erected a new species *Chiridota studeri* Théel, 1886, understanding the species to have 12 tentacles, hooks, and no wheels. Lampert (1889) retained *Chiridota studeri* Théel, but described material with 10 tentacles, hooks and wheels not in papillae. That material was *Holothuria* (*Fistularia*) *purpurea* Lesson. For the reasons given in the paragraph above we again agree with Ludwig's (1898) judgment that *Chiridota studeri* Théel, 1886 is a junior synonym of *Chiridota contorta* Ludwig.

In the same report Théel (1886a) described specimens from the Falkland Is as having 12 tentacles, scattered aggregations of wheels in the body wall, an absence of hooks, and minute rods in the muscle bands. He judged that this material from the Falkland Is was the true *Holothuria* (*Fistularia*) *purpurea* Lesson since it came from the type locality. We again agree with Ludwig's (1898) judgment that Théel's *Holothuria* (*Fistularia*) *purpurea* Lesson is *Chiridota pisanii* Ludwig (described in the same year 1886).

Ludwig (1891) included the two species *Chiridota studeri* Théel, 1886 and *Chiridota venusta* Semon, 1887 in his new genus *Trochodota* Ludwig, 1891. Ludwig (1898) subsequently changed the identification of his included species *Chiridota studeri* Théel, 1886 to *Trochodota purpurea* (Lesson, 1830).

Ossicle clusters in generic diagnosis

Dendy and Hindle (1907) remarked that in regard to wheels being grouped into papillae or scattered it was "undesirable to recognize any generic distinction between these two forms". In establishing the new species *Chiridota benhami* Dendy, 1909 (a junior synonym of *Chiridota dunedinensis* Parker, 1881) Dendy remarked that it was "clearly impossible to base generic distinctions merely upon the arrangement or even upon the presence or absence of the wheels". Joshua (1914) found the degree to which wheels were aggregated in *Trochodota allani* Joshua, 1912 varied greatly, and that "grouped" and "scattered" applied to wheels in this one species. H. L. Clark (1921) used the generic distinction in his key of "wheels gathered into sharply defined papillae" or "wheels scattered, often numerous enough to be crowded into ill-defined heaps". Rowe (1976) noted that for his species *Trochodota shepherdi* wheels are grouped into more than "ill-defined heaps" but not into papillae. He judged that the degree to which wheels were grouped was not a useful generic diagnostic character. Rowe also noted the anomaly that H. L. Clark (1921) used grouping of hooks for species distinction and grouping of wheels for generic distinction.

We have observed a range of wheel and hook arrangements in the body wall (see O'Loughlin and VandenSpiegel 2007). Wheels may be: clustered into discrete papillae, macroscopically noticeable as white spots, as in *Chiridota australiana* Stimpson,

1855, *Chiridota contorta* Ludwig, *Taeniogyrus heterosigmus* Heding, 1931 and *Taeniogyrus magnibaculus* Massin and Hétérier, 2004; or clustered into longitudinal interradial bands as in *Trochodota shepherdi* Rowe, 1976; or aligned in irregular bands adjacent to the longitudinal muscles as in *Trochodota roebucki* Joshua, 1914 and *Taeniogyrus tantulus* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); or loosely grouped into small clusters in larger specimens as in *Taeniogyrus antarcticus* Heding.

Hooks may be: grouped closely into small papillae as in *Chiridota australiana* Stimpson; aligned over and adjacent to the longitudinal muscles as in *Taeniogyrus papillis* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); aligned transversely in paired series over the edges of the longitudinal muscles as in *Trochodota roebucki* Joshua; scattered in all interradii as in *Taeniogyrus heterosigmus* Heding.

We judge that the arrangement of wheels and hooks in the body wall of chiridotid species may be useful as a species diagnostic character but not useful at generic level. A consequence is our synonymy below of *Trochodota* Ludwig, 1891 with *Taeniogyrus* Semper, 1867.

Wheel form in generic diagnosis

H. L. Clark (1921) thought that the teeth on the inner rim of the wheels of *Trochodota purpurea* were in groups. This was erroneous according to Smirnov (1997), and our observations. A figure of a wheel of *Chiridota purpurea* (as *Chiridota studeri* Théel) in Lampert 1889 (fig. 12a) does show a discontinuous series of teeth that are only over the spokes. This does not occur in any chiridotid wheels, and must be an error in illustration.

Rowe (1976) based his emended diagnoses of *Taeniogyrus* and *Trochodota* on the diagnostic character of wheels with continuous and those with discontinuous grouped teeth on the inner rim. Rowe (1976) considered *Trochodota purpurea* to be the type species for *Trochodota*, and followed H. L. Clark (1921) in thinking that the teeth on the inner rim of the wheels were discontinuous. *Trochodota* species were those with discontinuous series of teeth. As noted by Smirnov (1997) the Rowe review was unacceptable because the teeth are continuous around the rim in the type species.

O'Loughlin and VandenSpiegel (2007) followed the emended diagnosis of *Trochodota* by Rowe (1976). We now reject that position. But we agree with Rowe (1976) that the form of the wheels is useful at a generic diagnostic level, and erect a new genus to accommodate taeniogyrinid species with discontinuous series of teeth on the wheels.

Tentacle number in generic diagnosis

Tentacle number is not an inconsequential variable in apodid genera and species since it is interdependent with the structure of the calcareous ring. This is recognized in the diagnoses of genera of Myriotrochidae where species with 12 tentacles and two ring plates each with pairs of anterior projections are assigned to genus *Myriotrochus* Steenstrup, 1851, and those with 10 tentacles and single anterior projections on all 10 ring plates are assigned to genus *Prototrochus* Belyaev and Mironov, 1982. The Taeniogyrinae genera type species of *Taeniogyrus* Semper and *Trochodota* Ludwig have 10 plates in the calcareous ring and 10 tentacles, and the historical diagnostic character distinguishing the species of these two genera is the unsatisfactory degree to which wheels are grouped in the body wall. We judge that these two genera are synonyms, and raise the genus *Sigmodota* Studer, 1876, for which the type has 12 calcareous ring plates and 12 tentacles, out of synonymy to accommodate taeniogyrinid species with wheels, hooks and 12 tentacles.

Key to genera of subfamily Taeniogyrinae

1. Irregular thick spinous plates with wheel-spoked perforations present in body wall .... ***Archedota*** O'Loughlin (in O'Loughlin and VandenSpiegel)
— Lacking thick spinous plates in body wall 2
2. Lacking sigmoid hooks and chiridotid wheels in body wall .... ***Kolostoneura*** Becher
— Sigmoid hooks with or without chiridotid wheels in body wall 3
3. Sigmoid hooks only in body wall .... ***Scoliorhapis*** H. L. Clark
— Sigmoid hooks and chiridotid wheels in body wall 4
4. Chiridotid wheels with discontinuous series of teeth around inner rim of wheels .... ***Rowedota*** gen. nov.
— Chiridotid wheels with continuous series of teeth around inner rim of wheels 5
5. Tentacles 12, and 12 plates in calcareous ring .... ***Sigmodota*** Studer
— Tentacles 10, and 10 plates in calcareous ring .... ***Taeniogyrus*** Semper

Order **Apodida** Brandt, 1835 (sensu Östergren 1907)

Suborder **Myriotrochina** Smirnov, 1998

Diagnosis (Smirnov 1998). Ten or 12 digitate or peltato-digitate tentacles. Plates of calcareous ring with large anterior projections; excavations for tentacular ampullae are on anterior side of calcareous ring. Madreporite placed close to water ring. No ciliated funnels. One polian vesicle. Body wall ossicles represented by wheels with large numbers of spokes (8–25) and without a complex hub (single family Myriotrochidae).

Myriotrochidae Théel, 1877

Diagnosis. As for suborder.

Acanthotrochus antarcticus Belyaev and Mironov, 1981

Table 2

Acanthotrochus antarcticus Belyaev and Mironov, 1981a: 526–528, pl. 1(4–7), figs 3a–d, tables 3, 4.—Belyaev and Mironov, 1982: 108, fig. 18.

Table 2. Antarctic species of Apodida, and their distributions. *Chiridota pisanii* Ludwig* and *Taeniogyrus purpureus* (Lesson)* are listed but to date have not been recorded south of the Polar Front and are not Antarctic. Except for undescribed species, sources of data are given in the text.

Taxon	Distribution
Myriotrochidae Théel, 1877	
Acanthotrochus antarcticus Belyaev and Mironov, 1981	Eastern Antarctica, 65ºS 155ºE, 2800 m.
Acanthotrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2914 m.
Achiridota smirnovi sp. nov.	Prydz Bay, Amery Depression, Fram Bank, 518–788 m.
Myriotrochus antarcticus Smirnov and Bardsley, 1997	Eastern Antarctica, MacRobertson Shelf, 113 m; Western Antarctica, S Orkney Is, 216 m; Weddell Sea, 193 m.
Myriotrochus hesperides O'Loughlin and Manjón-Cabeza, 2009	Antarctic Peninsula, 65.47ºS 69.03ºW, 350 m.
Myriotrochus macquariensis Belyaev and Mironov, 1981	SW Pacific Ocean, Hjort Trench, 59ºS 158ºE, 3010–4640 m.
Myriotrochus nikiae sp. nov.	Eastern Antarctica, Ross Sea, 71ºS 175ºE, 2283 m.
Myriotrochus species (in Belyaev and Mironov 1982, p. 104)	Drake Passage, South Sandwich Trench.
Myriotrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, NW Weddell Sea, 2084–5190 m.
Neolepidotrochus variodentatus (Belyaev and Mironov, 1978)	South Sandwich Trench, 6766–7934 m.
Prototrochus barnesi sp. nov.	Scotia Sea, Shag Rocks, 206 m.
Prototrochus bipartitodentatus (Belyaev and Mironov, 1978)	South Sandwich Trench, 7700–8100 m.
Prototrochus linseae sp. nov.	Scotia Sea, South Shetland Is, 192–1544 m.
Prototrochus species (in Belyaev and Mironov 1982, pp. 92, 93)	South Sandwich Trench, 6050–6150 m.
Prototrochus species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2375–5190 m.
Chiridotidae Östergren, 1898	
**Chiridota pisanii* Ludwig, 1886	South America S of 42ºS, Falkland Is, Burdwood Bank, 0–102 m.
Kolostoneura griffithsi sp. nov.	Scotia Sea, South Orkney Is, 506 m.
Scoliorhapis biopearli sp. nov.	South Shetland Is, 1544 m.
Scoliorhapis massini sp. nov.	Scotia Sea, Shag Rocks, 206 m (? Falkland Is, 118 m).
Sigmodota contorta (Ludwig, 1875)	Antarctic Ocean, Bouvet I., South Georgia, S Shetland Is, S Orkney Is, 46–503 m. South America, south of 42° in the west, S of 47°S in the east. Indian Ocean, Heard, Kerguelen, Marion Is, 2–228 m. Indonesia, Java Sea, 82 m.
Sigmodota magnibacula (Massin and Hétérier, 2004)	Western Antarctica, Weddell Sea, S Orkney Is, 172–240 m. Eastern Antarctica, Ross Sea, Terre Adélie, Wilkes Land, Prydz Bay, MacRobertson Shelf, 8–525 m.
Taeniogyrus antarcticus Heding, 1931	Scotia Sea, S Orkney Is, South Georgia, Shag Rocks, 206–216 m.
Taeniogyrus prydzi sp. nov.	Eastern Antarctica, MacRobertson Shelf, 109–121 m; Prydz Bay Channel, Outfall slope, 795–830 m.
**Taeniogyrus purpureus* (Lesson, 1830)	Falkland Is; Magellanic region, 0–64 m.
Paradota weddellensis Gutt, 1990	Antarctic Ocean, Antarctic Peninsula, 126–265 m; Bellingshausen Sea, 97–1191 m; Ross Sea, 85–658 m; Prydz Bay, 505–578 m; Scotia Sea, 59–759 m; Weddell Sea, 225–655 m; Heard I., 120–215 m.
Synaptidae Burmeister, 1837	
Labidoplax species (by Bohn in Gebruk et al. 2003, p. 119)	South Orkney Is, 2893–3683 m.

Figure 1. Colour photos of preserved specimens of apodid species. a, *Prototrochus linseae* sp. nov. (7 mm long; S Shetland Is; holotype, NMV F168631); b, *Kolostoneura griffithsi* sp. nov. (12 mm long; insert drawings of tentacle rods, 96–112 μm long; S Orkney Is; holotype, NMV F168634); c, *Scoliorhapis biopearli* sp. nov. (6 mm long; insert drawing of tentacle rod, 115 μm long; S Shetland Is; holotype, NMV F168633); d, *Scoliorhapis massini* sp. nov. (20 mm long; Shag Rocks; holotype, NMV F168635); e, *Sigmodota magnibacula* (Massin and Hétérier, 2004) (15 mm long; S Orkney Is; NMV F168629); f, *Taeniogyrus antarcticus* Heding, 1931 (15 mm long; S Orkney Is; NMV F168630).

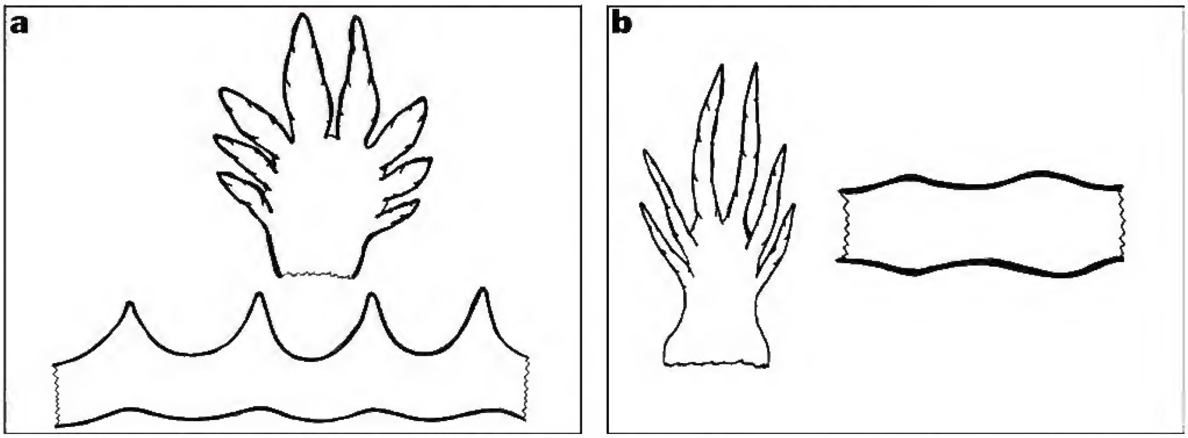

Figure 2. a, drawing of tentacle and part of non-calcareous ring of *Achiridota smirnovi* sp. nov. (Prydz Bay; holotype, NMV F68687); b, drawing of tentacle and part of calcareous ring of *Kolostoneura griffithsi* sp. nov. (S Orkney Is; holotype, NMV F168634).

Distribution. Eastern Antarctica, off Oates Land, Mawson Peninsula, 65°S 155° E, 2800 m.

Remarks. The distinguishing characters of species of *Acanthotrochus* Danielssen and Koren, 1879 are: wheel ossicles of more than one type, some with outward-pointing teeth on rim; wheels with outward pointing teeth lack inward-pointing teeth; anterior projections of the calcareous ring plates longer than the basal height of the plate; radial canal pore situated lower than the base of the anterior plate projection (see Gage and Billet 1986).

Achiridota Clark, 1908

Achiridota H. L. Clark, 1908: 126.—Heding, 1935: 16.—Smirnov, 1998: 521.

Diagnosis (of type species, following Fisher 1907, and Smirnov 1998). Tentacles 12, trunk stout, digits small; 6–8 pairs of digits per tentacle, increasing in size distally, distal digits paired not single; calcareous ring well developed, radial and interradial plates with anterior projection/tooth, straight posterior margin; lacking ossicles; single polian vesicle; madreporite at anterior edge of dorsal mesentery, close to ring canal; gonad tufts with central trunk and simple or dichotomous branches.

Type species. *Anapta inermis* Fisher, 1907 (Hawaiian Is, 466–772 m).

Other species. *Achiridota profunda* Heding, 1935 (N Atlantic, 2700 m); *Achiridota smirnovi* sp. nov. (E Antarctica, 518–788 m).

Remarks. *Achiridota* Clark, 1908 was initially assigned to Chiridotidae, but was subsequently assigned to Myriotrochidae by Smirnov (1998) on the basis of having: large anterior teeth on the plates of the calcareous ring; single polian vesicle; madreporite close to ring canal. Although Heding (1935) referred two new species to *Achiridota* he argued convincingly that one of his species (*Achiridota ingolfi* Heding, 1935) was more *Chiridota*-like because of the form of the calcareous ring and presence of 11 polian vesicles. We judge that *Achiridota ingolfi* belongs more appropriately in *Chiridota* Eschscholtz, 1829.

Achiridota smirnovi sp. nov.

Figure 2a; table 2

chiridotid sp. MoV 2019 O'Loughlin et al., 1994: 553, 554.

Material examined. Holotype. Eastern Antarctica, Prydz Bay, Amery Depression, 68°06'S 72°15'E, 788 m, stn ANARE AA93–60, M. O'Loughlin, 28 Jan 1993, NMV F68687.

Paratype. Prydz Bay, edge of Fram Bank, 66°55'S 69°12'E, 518 m, stn ANARE AA93–75, 31 Jan 1993, NMV F68686.

Diagnosis. Achiridotid species up to 15 mm long (posterior end of body missing on 11 mm long holotype); 12 peltato-digitate tentacles, 4 pairs of digits per tentacle, pair distally, increasing in size distally; tentacle ampullae cup-like, on anterior edge of non-calcareous ring; lacking ossicles in body wall, tentacles; lacking calcareous ring; single polian vesicle; madreporite on long straight canal; gonad tubules with multiple branching; lacking ciliated funnels.

Colour (preserved). Holotype with reddish-brown flecking on semi-translucent off-white body, red-brown tentacles; other specimen semi-translucent off-white, tentacles pale reddish-yellow.

Distribution. Eastern Antarctica, Prydz Bay, 518–788 m.

Etymology. Named for Alexei Smirnov (Zoological Institute of the Russian Academy of Sciences, St. Petersburg) in recognition of his description of the first myriotrochid species from the Antarctic shelf, and with appreciation of his significant contribution to the systematics of Apodida.

Remarks. Apodid specimens collected from Prydz Bay during the same cruise as these specimens, and preserved in the same way (directly in 70% ethanol), have retained their ossicles in good or slightly eroded condition. It is most unlikely that the complete absence of calcareous parts in the two specimens on which *Achiridota smirnovi* sp. nov. is based is a result of preservation.

Generic assignment of this new species is problematic because of the absence of a calcareous ring and body wall ossicles. But the tentacles do arise from anterior cup-like depressions around the non-calcareous ring, as in *Achiridota* H. L. Clark. The species has the *Achiridota* diagnostic characters of: 12 peltato-digitate tentacles; single polian vesicle; lacking ossicles in tentacles, body wall; lacking ciliated funnels. But the madreporite is situated at the end of a long straight canal, and is not close to the water canal. We assign the new species to *Achiridota* Clark with reservations because of the absence of a calcareous ring and position of the madreporite distant from the ring canal. These two characters distinguish *Achiridota smirnovi* sp. nov. from *Achiridota inermis* (Fisher) and *Achiridota profunda* Heding. Additional diagnostic distinctions are the presence of 6–8 pairs of tentacle digits in *Achiridota inermis* (4 pairs in *A. smirnovi*), and 7–8 pairs of tentacle digits and unbranched gonad tubules in *Achiridota profunda* (branched in *A. smirnovi*).

Myriotrochus Steenstrup, 1851

Diagnosis (following Gage and Billet 1986). Myriotrochid with 12 tentacles; calcareous ring bilaterally symmetrical; dorsolateral radial plates with two anterior projections; wheel ossicles of one type with rim teeth pointing only towards centre of hub; wheel hub lacking holes, and if holes are present they are distributed regularly in a circle around the centre of the hub; rod ossicles absent.

Myriotrochus antarcticus Smirnov and Bardsley, 1997

Figures 3, 4; table 2

Myriotrochus sp. MoV 2039 O'Loughlin et al., 1994: 553, table 2.
Myriotrochus antarcticus Smirnov and Bardsley, 1997: 109–111, fig. 1, table 1.—O'Loughlin et al. 2009: 9.

Material examined. Holotype. Eastern Antarctica, 66°55'S 62°32'E, 113 m, M. O'Loughlin, 11 Feb 1993, NMV F69125.

Other material. Western Antarctica, South Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB–EBS–4, 18 Mar 2006, NMV F168638 (1); F168643 (1 whole, for molecular sequence, tissue code MOL AF 805); RBINS IG 31 459 (2 whole, for SEM figures); NHM 2010.48–49 (2); Weddell Sea, 71.25° S 13.00° W, 193 m, RBINS 628686 (1).

Diagnosis (following Smirnov and Bardsley 1997 for Prydz Bay holotype). Myriotrochid species up to 8 mm long; 12 peltato-digitate tentacles, up to 8–12 digits per tentacle, distalmost pair longest; lacking tentacle ossicles; calcareous ring comprising 10 plates, ventral plates not significantly longer than dorsal plates; two dorsolateral radial plates each with 2 prominent tapering anterior projections, remaining plates with single prominent tapering anterior projection; posterior margin of calcareous ring slightly undulating, not concave; ossicles myriotrochid wheels only, scattered sparsely and uniformly throughout body wall; wheels of one type, all teeth pointing to centre of hub; wheel ossicle diameters 140–150 μm (for S Orkneys specimens 80–144 μm; for Weddell Sea specimen 108–133 μm), spokes 15–16 (for S Orkneys 13–16; for Weddell Sea 13–15), teeth 22–24 (for S Orkneys 19–25; for Weddell Sea 22–24), spokes/teeth % 66.7–68.2 (for South Orkneys 64–68; for Weddell Sea 60.8–65.2), hub diameter/wheel diameter % 18.0–18.6 (for S Orkneys 16.0–18.1), teeth length/wheel diameter % 18.0–18.6 (for S Orkneys 14.4–16.0).

Colour (preserved). Body grey, translucent; tentacles white.

Distribution. Antarctic shelf species; Eastern Antarctica, western MacRobertson Shelf, 113 m; Western Antarctica, South Orkney Is, 216 m; Weddell Sea, 193 m (range 113–216 m).

Remarks. For *Myriotrochus antarcticus* Smirnov and Bardsley, 1997 there are only minor morphological differences for the limited number of measurements for specimens from the Scotia Sea, Weddell Sea and Prydz Bay, suggesting a morpho-species with an eastern and western Antarctic distribution.

Myriotrochus hesperides O'Loughlin and Manjón-Cabeza, 2009

Figure 5a; table 2

Myriotrochus hesperides O'Loughlin and Manjón-Cabeza (in O'Loughlin et al., 2009): 9, fig. 2e, f, table 1.

Diagnosis (following O'Loughlin et al. 2009). Myriotrochid species up to 13 mm long; 12 peltato-digitate tentacles, about 7 small rounded digits per tentacle; lacking tentacle ossicles; plates of calcareous ring asymmetrical with pointed anterior projections / teeth, 2 radial plates each with 2 anterior projections, remaining plates with single anterior projection, wide rounded tongue-like posterior projections of variable length; ossicles myriotrochid wheels only, few only in posterior dorsal body wall; wheels of one type, all teeth pointing towards centre of hub; spokes irregular, about half branching proximally, some branches not reaching rim, some spokes with cross-connections; teeth variably sub-equal or different in size; hubs small, irregular, not disc-like, lacking perforations, formed by junction of spokes; largest wheel with diameter 248 μm, hub diameter 40 μm, 13 spokes at hub, 23 spokes at rim, 30 equal teeth; smallest wheel with diameter 200 μm, hub diameter 24 μm, 12 spokes at hub, 16 spokes at rim, 28 unequal teeth.

Distribution. Antarctic Peninsula, 65.47°S 69.03°W, 350 m.

Remarks. *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza, 2009 was the second Antarctic shelf *Myriotrochus* species to be described. Amongst *Myriotrochus* species it is closest to *Myriotrochus clarki* Gage and Billett, 1986 from the Rockall Trough in the N Atlantic at 1605–2515 m. The species are distinguished in O'Loughlin et al. 2009.

Myriotrochus macquariensis Belyaev and Mironov, 1981

Table 2

Myriotrochus macquoriensis Belyaev and Mironov, 1981b: 169–170, fig. 4, tables 3, 4, pl. figs 4, 5.—Belyaev and Mironov, 1982: 105, fig. 15.

Distribution. SW Pacific/Antarctic Ocean, Hjort Trench, 59°S 158°E, 3010–4640 m.

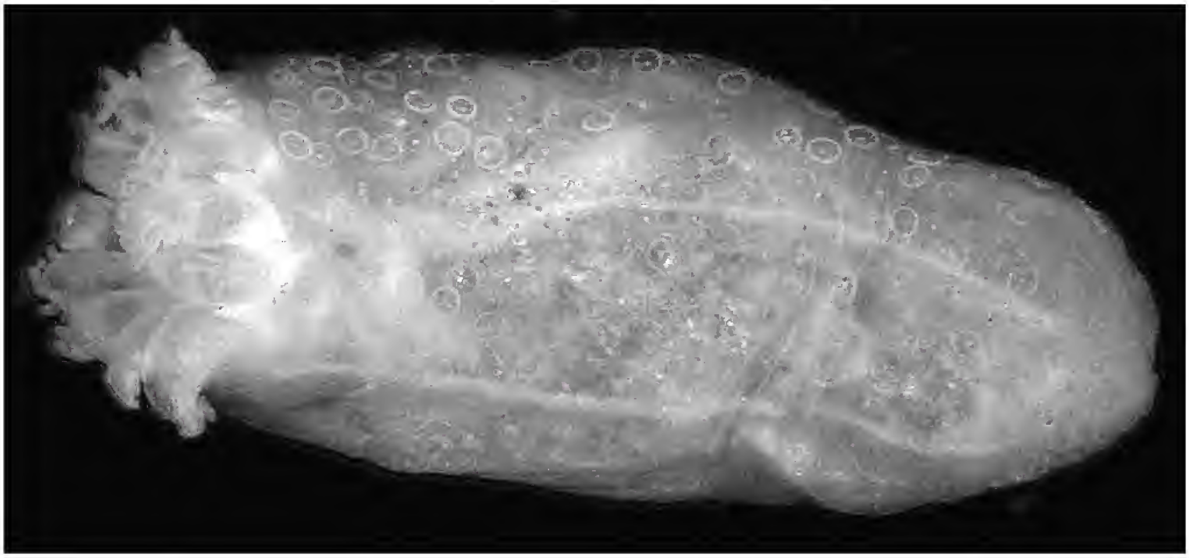

Figure 3. Photo of *Myriotrochus antarcticus* Smirnov and Bardsley, 1997, showing 12 peltato-digitate tentacles, calcareous ring with high anterior pointed projections, and wheels distributed throughout body wall (7 mm long; S Orkney Is, 216 m; RBINS IG 31 459).

Remarks. The spelling of the species name is corrected as reported at the beginning of this paper.

Myriotrochus nikiae sp. nov.

Figure 5b; table 2

Material examined. Holotype. Antarctica, Ross Sea, 71.23° S 174.44° E, 2281–2283 m, NZ IPY–CAML stn TAN0802/171, N. Davey, 26 Feb 2008, NIWA 37812 (in two parts).

Diagnosis. Myriotrochid species up to 33 mm long (2 parts combined); body wall thick, soft; 12 tentacles, withdrawn; lacking tentacle ossicles; calcareous ring comprising 10 plates; two dorsolateral radial plates each with 2 prominent tapering anterior projections, remaining plates with single prominent tapering anterior projection; posterior margin of calcareous ring slightly undulating, not concave; sac-like calcareous madreporite, dorsal, close to ring; single ventral polian vesicle; gonad comprises thick digitiform unbranched tubules arising in a series along gonoduct, 9 on one side of mesentery; ossicles in body wall myriotrochid wheels only, found throughout body wall; wheels of one type, all teeth pointing to centre of hub; hub large and disc-like, perforated, with regular circle of perforations separated by sometimes irregular hub spokes aligned with longer outer wheel spokes, some hub spokes branched distally; teeth blunt and rounded, of irregular length, generally longer over spokes than between spokes.

Measurements for 9 wheels: wheel ossicle diameters 320–400 μm, hub disc diameters 168–216 μm, inner hub diameter 24–32 μm, teeth length 48 μm, spokes 11–15, teeth 22–36, spokes/teeth % 36–50, hub disc diameter/wheel diameter % 51–52, teeth length/wheel diameter % 12–15.

Colour (preserved). Body grey, not translucent; few small dark brown spots on tentacles.

Distribution. Eastern Antarctica, Ross Sea, 2283 m.

Etymology. Named for Niki Davey (NIWA), with appreciation of her generous and skilled collaborative assistance in determining Antarctic and New Zealand holothuroids.

Remarks. The specimen size, grey colour, form and size of the wheels, and form of the calcareous ring of *Myriotrochus nikiae* sp. nov. are similar to those of *Myriotrochus bathybius* H. L. Clark, 1920 from the eastern tropical Pacific Ocean (4°33'S 87°43'W, 3669 m), and according to Gage and Billett (1986) from the northeast Atlantic Ocean (Rockall Trough, 1800–2925 m, and Porcupine Seabight, 3680–4310 m). Gage and Billett (1986) further judged *Myriotrochus bathybius* to be cosmopolitan at abyssal depths. Differences are such that we judge that the Antarctic specimen represents a related but different species.

For *Myriotrochus bathybius*, Clark (1920) gave three wheel diameters of 240, 300 and 340 μm (size range smaller than for *M. nikiae*), and two teeth counts of 37 and 38 (more numerous than for *M. nikiae*). More significant for us is a wheel of *M. bathybius* that was illustrated in Clark 1920, and the teeth are uniform in length and distinctly pointed. Smirnov (1999, fig. 4) illustrated similar teeth for *Myriotrochus (Oligotrochus) bathybius*. The form of these teeth is in contrast with the irregular lengths of the quite rounded teeth of *M. nikiae*. Clark (1920) noted seven dark spots between tentacle bases. These are not present in the Antarctic specimen, but some dark spots are present on the tentacles.

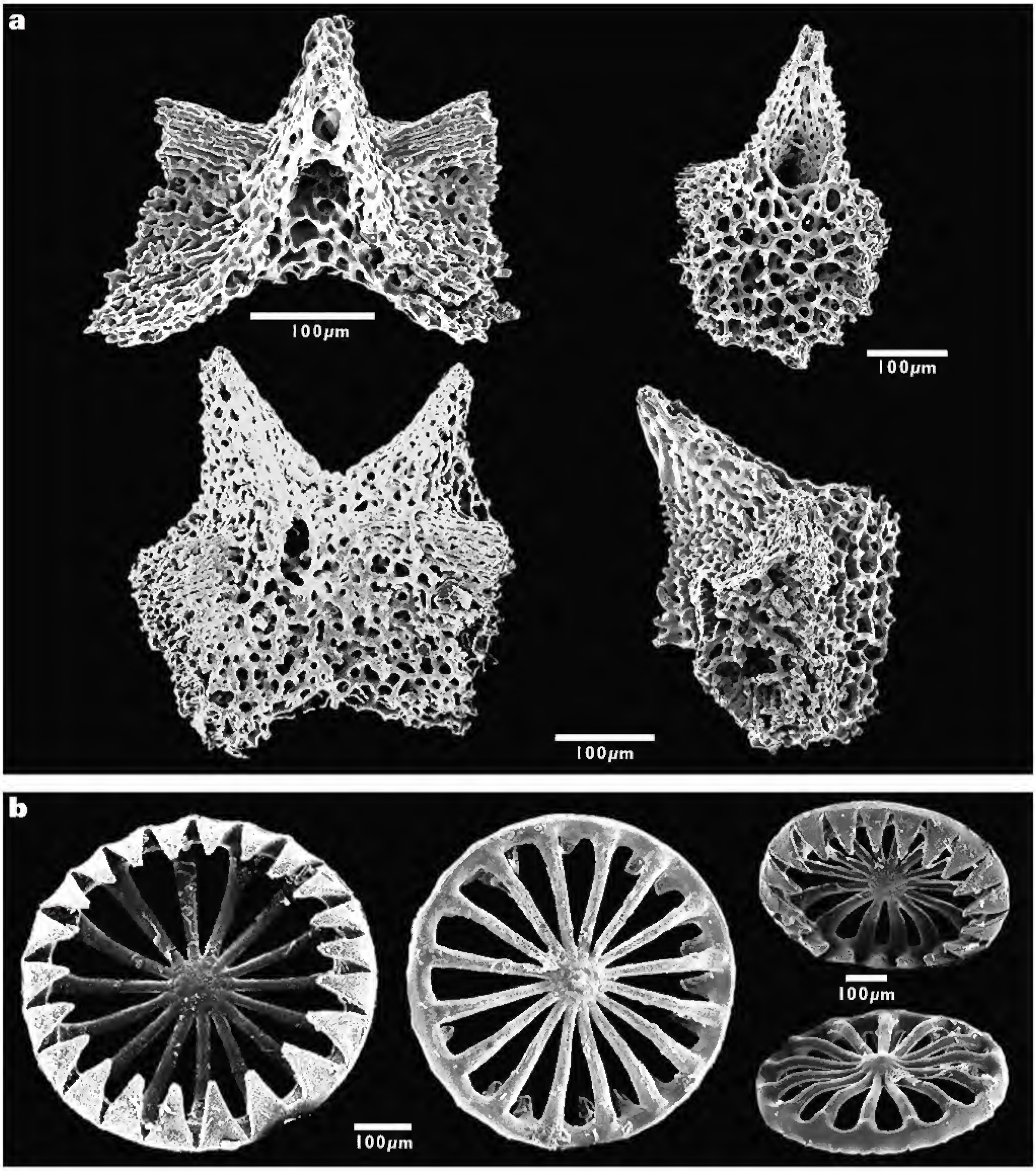

Figure 4. *Myriotrochus antarcticus* Smirnov and Bardsley, 1997 (S Orkney Is, 216 m; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent anterior projections and undulating posterior margin and canals, dorso-lateral radial plate (lower left) with two anterior projections; b, SEM of wheels from the body wall.

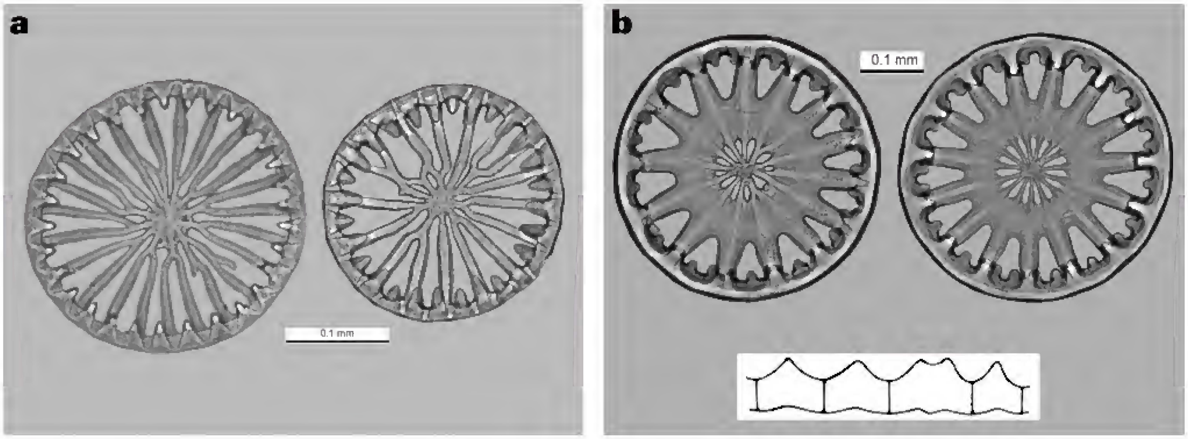

Figure 5. a, montage photo of wheels from body wall of holotype of *Myriotrochus hesperides* O'Loughlin and Manjón-Cabeza, 2009 (Antarctic Peninsula; slide NMV F161516); b, montage photos of wheels from body wall of holotype of *Myriotrochus nikiae* sp. nov., with insert drawing of dorso-lateral radial (2 anterior projections) and adjacent inter-radial (single anterior projection) plates from calcareous ring (Ross Sea; NIWA 37812).

For *Myriotrochus bathybius*, Gage and Billett (1986) reported a possible rough texture of the body wall in larger specimens (soft, thick body wall for *M. nikiae*), and the calcareous ring clearly visible through the body wall (not visible through the thick body wall of *M. nikiae*). Gage and Billett (1986) illustrated tapered teeth of uniform length with narrowly rounded points (in contrast with the bluntly rounded teeth of variable length for *M. nikiae*).

As noted in the diagnosis the tentacles of the single specimen of *Myriotrochus nikiae* are withdrawn, and it was not possible to confidently describe them as "conical with lateral digits" or "peltato-digitate" as required for assignment to subgenus *Oligotrochus* M. Sars or subgenus *Myriotrochus* Steenstrup respectively (see Smirnov 1999).

Neolepidotrochus variodentatus (Belyaev and Mironov, 1978)

Table 2

Myriotrochus variodentatus Belyaev and Mironov, 1978: 202–204, fig. 4, tables 1, 4, pl. 1 figs 4–6, 9.

Lepidotrochus variodentatus.—Belyaev and Mironov, 1980: 1812, 1818, tables 1, 5.—Belyaev and Mironov, 1982 : 109, fig. 18.

Neolepidotrochus variodentatus.—Bohn, 2005: 234.

Distribution. South Sandwich Trench, 6766–7934 m.

Remarks. Bohn (2005) recognized that *Lepidotrochus* Belyaev and Mironov, 1980 is a junior homonym of *Lepidotrochus* Koken, 1894, and erected the replacement name *Neolepidotrochus*. The distinguishing characters of species of *Neolepidotrochus* Bohn, 2005 are: wheel ossicles with outward-pointing teeth also have inward-pointing teeth; anterior projections of the calcareous ring plates are lower than the basal height of the plates; radial canal pore is situated higher than the base of the anterior plate projection (see Gage and Billet 1986).

Prototrochus Belyaev and Mironov, 1982

Diagnosis (after Gage and Billett 1986). Myriotrochid with 10 tentacles; calcareous ring symmetrical, with dorsal and ventral plates subequal in size; dorsolateral radial plates with single anterior projection; wheels with teeth distributed regularly, pointing towards centre of hub; rods absent from body wall, sometime occurring in and around tentacles.

Remarks. Belyaev and Mironov (1982) noted in erecting their new genus *Prototrochus* that the wheels of their included species *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) were exceptional within their diagnosis as there are small external teeth at the base of the internal teeth.

Prototrochus barnesi sp. nov.

Figure 6; table 2

Material examined. Holotype. Antarctica, Scotia Sea, Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, 11 Apr 2006, NMV F168637.

Paratypes. Type locality and date, NHM 2010.54 (1); RBINS IG 31 459 (1, SEM).

Diagnosis. Myriotrochid species up to 3 mm long; 10 peltato-digitate tentacles, 7 digits per tentacle, including a distal terminal one; tentacle rods present, straight and curved, some with central swelling, some with swollen end, 40–170 μm long; sparse myriotrochid wheels in body wall, slightly scalloped margin at each tooth; wheel ossicle diameters 72–104 μm, spokes 13–15, teeth 22–27, spokes/teeth % 50–59, hub diameters 19–26 μm, hub diameter/wheel diameter % 25–38, teeth length/wheel diameter % 12–20.

Colour (preserved). Off-white.

Distribution. Western Antarctica, Scotia Sea, Shag Rocks, 206 m.

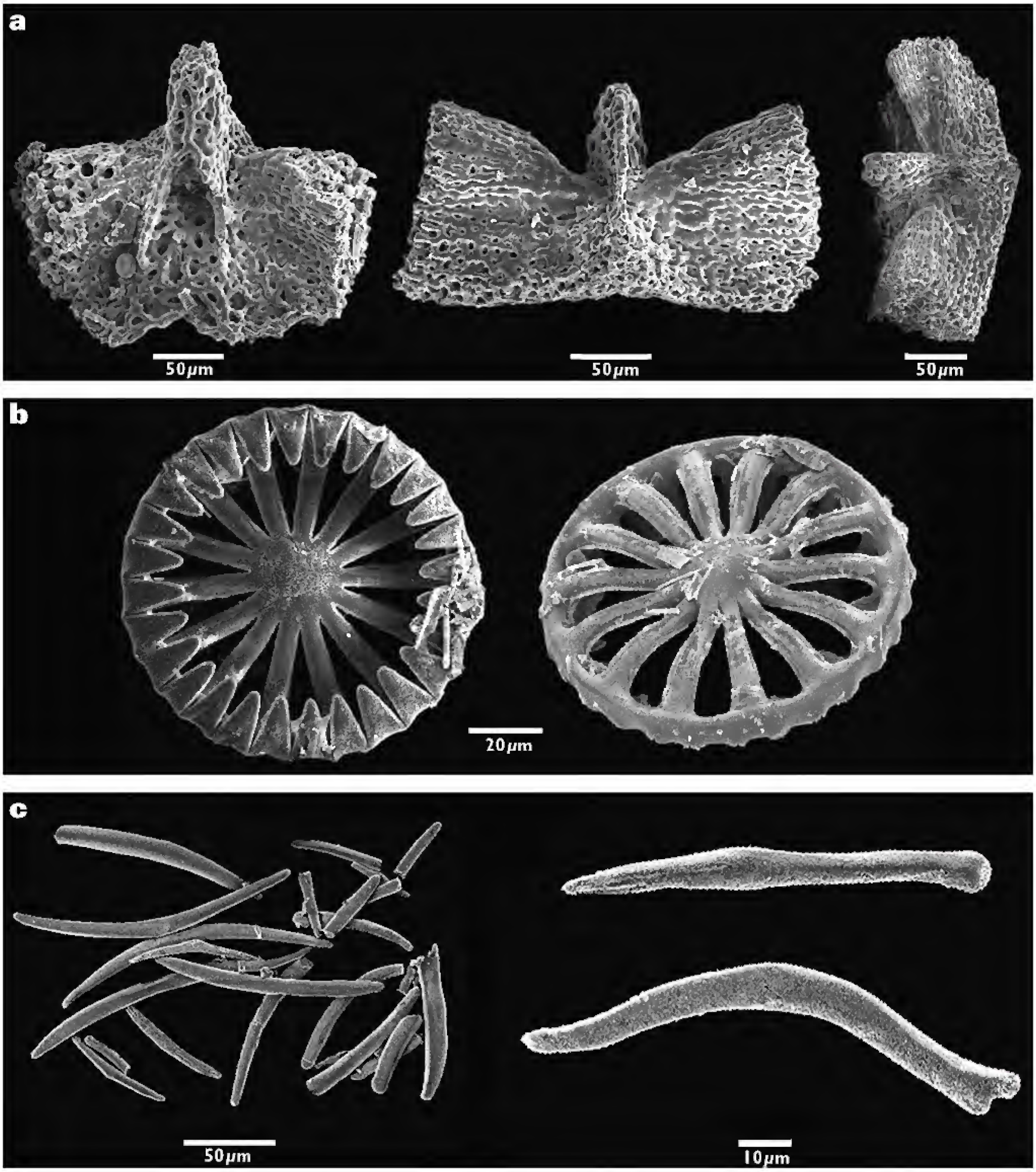

Figure 6. *Prototrochus barnesi* sp. nov. (Shag Rocks; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent single anterior projections; b, SEM of wheels from the body wall; c, SEM of rods from tentacles.

Etymology. Named for David Barnes (British Antarctic Survey), in appreciation of his role in the BAS BIOPEARL expeditions and the collection of specimens studied here.

Remarks. Belyaev and Mironov (1982) referred 12 species to their new genus *Prototrochus*. O'Loughlin and VandenSpiegel (2007) added three new *Prototrochus* species from the continental slope of Australia, all lacking tentacle ossicles. The only *Prototrochus* species recorded from Antarctica is *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) from the South Sandwich Trench at 7700–8100 m. This species lacks tentacle rods and has external teeth around the rim of the wheels. *Prototrochus barnesi* sp. nov. has wheels with internal teeth only, and has tentacle rods, a rare character for *Prototrochus* species. The only other *Prototrochus* species with tentacle rods is the similarly small *Prototrochus minutus* (Östergren, 1905), described from the coast of Korea at 60–65 m depth. Three diagnostic characters distinguish *Prototrochus minutus* from *Prototrochus barnesi*: sometimes distally and centrally branched tentacle rods; longer tentacle rods (mostly 140–200 μm long); significantly larger wheels (mostly 100–150 μm diameter).

Prototrochus bipartitodentatus (Belyaev and Mironov, 1978)

Table 2

Myriotrochus bipartitodentatus Belyaev and Mironov, 1978: 201–202, fig. 3, tables 1, 3, pl. 1 fig. 1.

Prototrochus bipartitodentatus.—Belyaev and Mironov, 1982: 86, 92, fig. 6.

Distribution. South Sandwich Trench, 7700–8100 m.

Remarks. *Prototrochus bipartitodentatus* (Belyaev and Mironov) is distinguished from all other *Prototrochus* species by the presence of small external teeth at the base of the internal teeth of the wheels.

Prototrochus linseae sp. nov.

Figures 1a, 7; table 2

Material examined. Holotype. Antarctica, Scotia Sea, South Shetland Is, 62.53°S 61.83°W, 192 m, BAS stn LI–EBS–4, 4 Mar 2006, NMV F168631.

Paratypes. Type locality and date, NHM 2010.50 (1); RBINS IG 31 459 (2, SEM).

Other material. South Shetland Is, 61.61°S 55.22°W, 1544 m, BAS stn EI–EBS–1, 12 Mar 2006, NHM 2010.53 (1).

Diagnosis. Myriotrochid species up to 7 mm long; 10 tentacles; lacking tentacle rods; scattered myriotrochid wheels only in body wall; wheel ossicle diameters 125–137 μm, spokes 10–11, teeth 22–24, spokes/teeth % 45, hub diameters 30–34 μm, hub diameter/wheel diameter % 24.0–24.7, teeth length/wheel diameter % 12.9–13.0.

Colour (preserved). Body pale yellow-brown to off-white, translucent; tentacles yellow.

Distribution. Antarctica, Scotia Sea, South Shetland Is, 192–1544 m.

Etymology. Named for Katrin Linse (British Antarctic Survey), in appreciation of her role in the BAS BIOPEARL expeditions and the collection of specimens studied here, and with gratitude for her gracious collaboration in making BAS specimens available for this study and providing relevant data.

Remarks. Most of the 12 species referred to their new genus *Prototrochus* by Belyaev and Mironov (1982) lack tentacle ossicles, as does *Prototrochus linseae* sp. nov. Most of the species lacking tentacle ossicles are from the deep trenches (6450–10700 m in Belyaev and Mironov 1882). Only *Prototrochus bipartitodentatus* (Belyaev and Mironov, 1978) has been recorded from the Antarctic (South Sandwich Trench, 7700–8100 m). It has external teeth around the rim of the wheels that *Prototrochus linseae* does not. Belyaev and Mironov (1982) list three shallower species (540–3000 m), two from the Mediterranean Sea and *Prototrochus australis* (Belyaev and Mironov, 1981) from the Tasman Sea. O'Loughlin and VandenSpiegel (2007) list three additional species from the Tasman Sea: *Prototrochus burni* O'Loughlin, 2007*, *Prototrochus staplesi* O'Loughlin, 2007* and *Prototrochus taniae* O'Loughlin, 2007* (*all in O'Loughlin and VandenSpiegel 2007). As demonstrated by reference to Table 1 and Figure 10 in O'Loughlin and VandenSpiegel (2007), *Prototrochus linseae* is distinguished from the four Tasman Sea *Prototrochus* species by the form of the wheels: smallest wheels; largest teeth; widest uniformly broad spokes, with sharp constriction at the hub; largest hub.

Suborder **Synaptina** Smirnov, 1998

Diagnosis (Smirnov, 1998). Plates of calcareous ring without prominent anterior projections; excavations for tentacular ampullae lie on outer side of calcareous ring. Madreporite situated far from water ring at end of long stone canal. Ciliated funnels present. One to many polian vesicles. Body wall ossicles may be wheels of chiridotid type with 6 spokes and a complex hub and/or sigmoid hooks, or anchors and anchor plates. Wheels of larvae and juveniles with more spokes and small denticles on inner side of rim.

Families. Chiridotidae Östergren, 1898; Synaptidae Burmeister, 1837.

Chiridotidae Östergren, 1898

Diagnosis (Smirnov 1998). Synaptina with 10, 12 or 18 peltato-digitate, pinnate or bifurcate tentacles. Juveniles with bifurcate tentacles. Body wall ossicles wheels of chiridotid type and/or sigmoid hooks. Chiridotid type wheels with 6 spokes, numerous small denticles on inner side of rim and a complex hub; on lower side of each spoke a branch leans against the lower end of the hub forming a star structure. Ossicles in tentacles usually rods with branched ends.

Subfamilies. Taeniogyrinae Smirnov, 1998; Chiridotinae Östergren, 1898 (sensu Smirnov 1998).

Subfamily **Taeniogyrinae** Smirnov, 1998

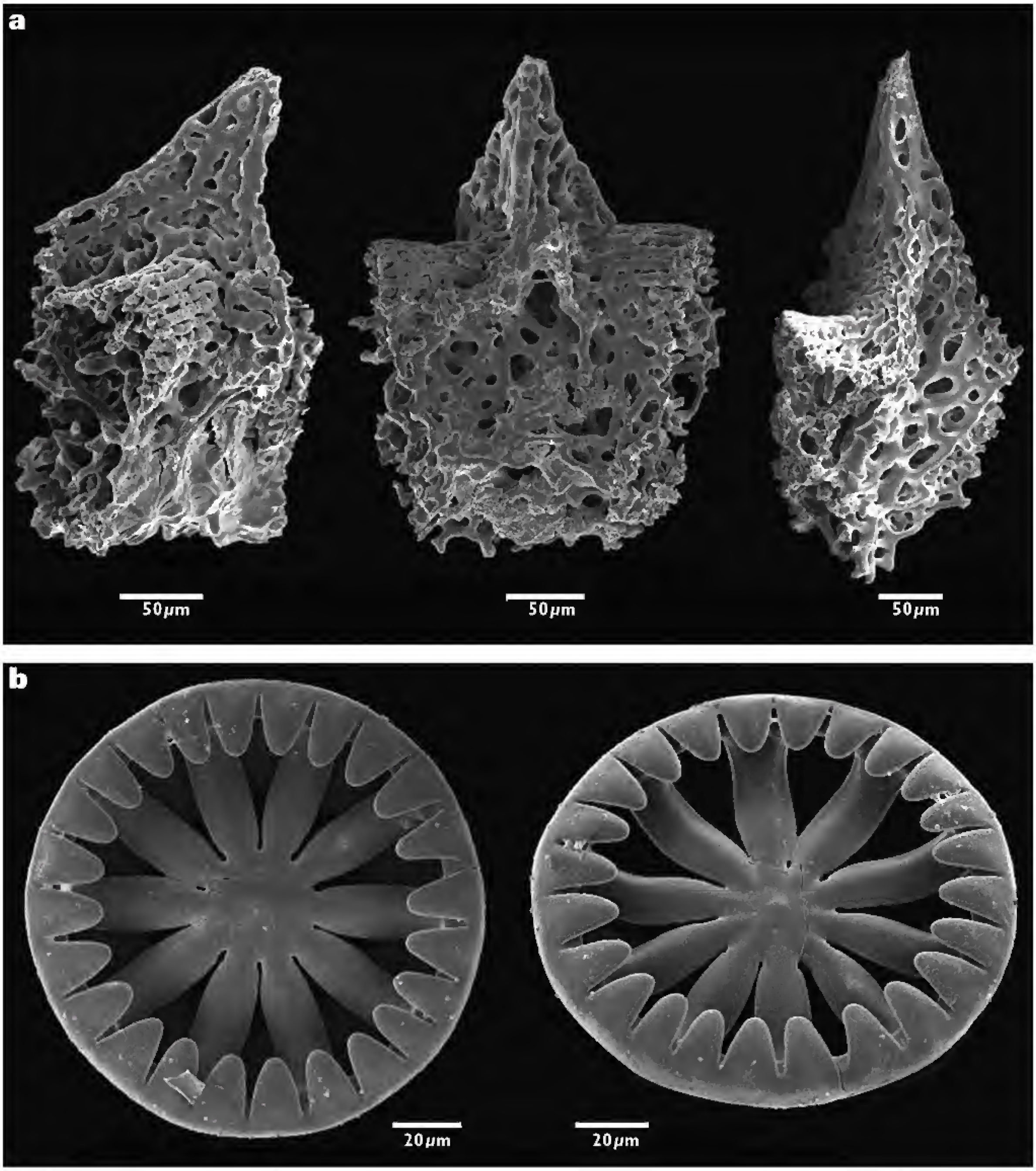

Figure 7. *Prototrochus linseae* sp. nov. (S Shetland Is; RBINS IG 31 459). a, SEM of plates of the calcareous ring with prominent single anterior projections; b, SEM of wheels from the body wall.

Diagnosis (Smirnov 1998). Chiridotidae with 10 or 12 tentacles. Body wall ossicles wheels of chiridotid type and sigmoid hooks or sigmoid hooks only. Radial plates of calcareous ring not perforated but sometimes slightly notched in anterior (upper) face for passage of nerves.

Included genera. Archedota O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel 2007); *Kolostoneura* Becher, 1909; *Rowedota* gen. nov.; *Scoliorhapis* H. L. Clark, 1946; *Sigmodota* Studer, 1876; *Taeniogyrus* Semper, 1867.

Remarks. Achiridota Clark, 1908 was initially placed in Chiridotidae, but was assigned to Myriotrochidae by Smirnov (1998) on the basis of having: large anterior teeth on the plates of the calcareous ring; single polian vesicle; madreporite close to calcareous canal. *Sigmodota* Studer is raised out of synonymy with *Taeniogyrus* Semper (below). *Trochodota* Ludwig, 1891 is made a junior synonym of *Taeniogyrus* Semper (below). *Scoliodotella* Oguro, 1961 is made a junior synonym of *Scoliorhapis* H. L. Clark (below).

Kolostoneura Becher, 1909

Kolostoneura Becher, 1909: 42.—H. L. Clark, 1921: 164.—Mortensen, 1925: 384–386.—Heding, 1928: 277, 278.—Pawson, 1970: 44.—Smirnov, 1998: 519.

Diagnosis (of type species, following Dendy and Hindle 1907 and Mortensen 1925). Taeniogyrinid genus with 10 peltato-digitate tentacles, each with 12 digits increasing in size distally; tentacle rods present; lacking ossicles in body wall; calcareous ring present, 5 subrectangular, transversely elongate radial and 5 subequal, interradial plates, lacking anterior projections / teeth; single polian vesicle; madreporite canal long, straight, madreporite distant from water ring; branched gonad tubules; ciliated funnels present.

Type species. Rhabdomolgus novae-zealandiae Dendy and Hindle, 1907 (New Zealand, Chatham Is, coastal shallows).

Other species. Kolostoneura griffithsi sp. nov. (Antarctica, Scotia Sea, 506 m).

Remarks. Smirnov (1998) noted that although *Kolostoneura* lacks ossicles in the body wall its morphological characters place it near *Taeniogyrus* and *Trochodota* and thus in family Taeniogyrinae. Mortensen (1925) found a very small, damaged specimen that he judged to be *Kolostoneura novae-zealandiae* (Dendy and Hindle) that was infested with parasitic snails and had hooks and wheels in the body wall. He postulated that the ossicles of the ancestral species were present through the influence of the parasite. Perhaps ossicles are typically present in small specimens of this species, and then lost as size increases as happens with many holothuroid species (such as with the apodid *Taeniogyrus magnibaculus* Massin and Hétérier, 2004 below). If this is the case then genus *Kolostoneura* would be a junior synonym of *Taeniogyrus* Semper, 1867 (see below).

Kolostoneura griffithsi sp. nov.

Figures 1b, 2b; table 2

Material examined. Holotype. South Orkney Is, 60.99°S 46.83°W, 506 m, BAS stn PB–EBS–3, 18 Mar 2006, NMV F168634.

Diagnosis. Taeniogyrinid species 12 mm long; 10 peltato-digitate tentacles, 3–4 pairs of digits per tentacle; no ossicles in body wall; tentacle rods present, some with central hub, some with bifurcate ends, 96–112 μm long; solid calcareous ring, plates lack anterior projections/teeth, posterior margin slightly concave; single polian vesicle; madreporite with short curved canal, close to water ring; gonad tubules not present; lacking ciliated funnels.

Colour (preserved). Dark purple-red flecking on grey to off-white semi-translucent body wall.

Distribution. Antarctica, Scotia Sea, South Orkney Is, 506 m.

Etymology. Named for Huw Griffiths (British Antarctic Survey), in appreciation of his role in the BAS BIOPEARL expeditions and the collection of specimens studied here.

Remarks. Kolostoneura griffithsi sp. nov. exhibits the diagnostic characters of the type species of *Kolostoneura* Becher, 1909, except that it has fewer tentacle digits, has calcareous ring plates that are not transversely elongate, and lacks ciliated funnels. However, Mortensen (1925) noted that ciliated funnels were sometimes scarce or absent along the mesentery in the material that he examined.

Rowedota gen. nov.

Figure 8

Diagnosis. Taeniogyrinid genus with 10 tentacles, each with 1–4 pairs of digits; chiridotid-type wheels and sigmoid hooks in body wall, rods in tentacles; wheels with teeth on inner rim in 6 discrete groups, discontinuous between spokes, not continuous series around rim; wheels scattered or aligned in the body wall, not in distinct papillae; sigmoid hooks scattered; single polian vesicle; ciliated funnels present.

Type species. Taeniogyrus allani Joshua, 1912 (see O'Loughlin and VandenSpiegel 2007).

Other species. Trochodota epiphyka O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Trochodota shepherdi* Rowe, 1976; *Trochodota vivipara* Cherbonnier, 1988; *Trochodota mira* Cherbonnier, 1988.

Etymology. Named for Dr Frank W. E. Rowe, Senior Fellow of the Australian Museum, with appreciation of his contribution to echinoderm systematics and of his role as a valued mentor and colleague.

Remarks. Rowe (1976) based his emended diagnoses of *Taeniogyrus* and *Trochodota* on an important diagnostic character that distinguished two types of wheels amongst species of Taeniogyrinae, namely those with a continuous series and those with discontinuous grouped teeth on the inner rim. We judge that this is a significant generic character and on this diagnostic character erect the new genus. The genus has further morphological coherence with all included species having 10 tentacles, up to only 4 pairs of tentacle digits, a single

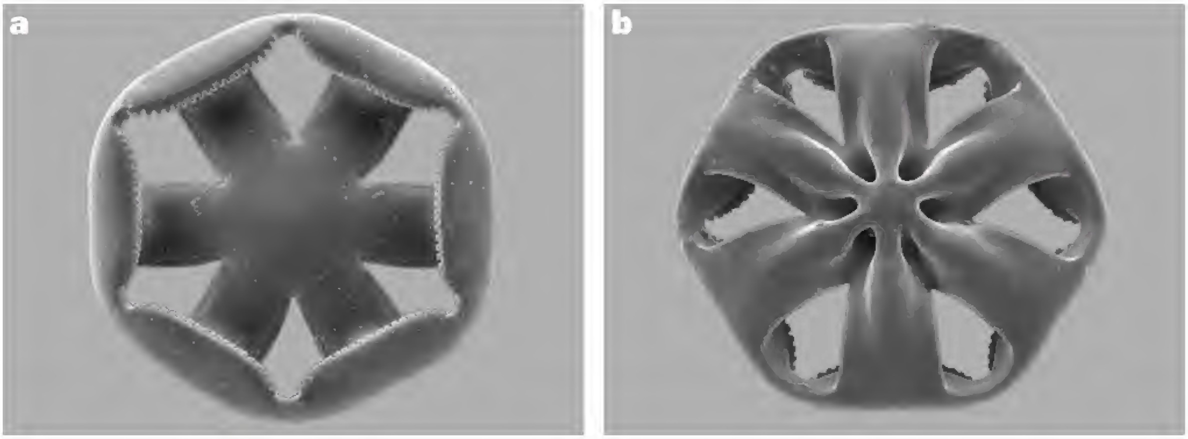

Figure 8. a, b, SEM of wheels from body wall of *Rowedota allani* (Joshua, 1912) illustrating the *Rowedota* gen. nov. generic character of discontinuous series of teeth around the inner rim (SE Australia; from lot NMV F82715).

polian vesicle, and the wheels never grouped into discrete papillae or bands. The new genus has geographical coherence with all included species occurring on both sides of the Indian Ocean off Australia and Madagascar.

We have included the presence of a single polian vesicle and ciliated funnels in the generic diagnosis of *Rowedota* gen. nov., but the presence of ciliated funnels in the Cherbonnier (1988) species and presence of a single polian vesicle in *Trochodota mira* have yet to be confirmed.

Frank Rowe (pers. comm.) considers the rods in the body wall illustrated by Cherbonnier (1988) for his *Trochodota mira* to be contaminants. Species to date referred to *Trochodota*, other than those referred here to the new genus *Rowedota*, are referred to *Taeniogyrus* (below). The wheels of *Trochodota maculata* H. L. Clark, 1921 have continuous series of teeth in the inner rim (see below). Rowe (1976) followed Clark (1921) who thought that the wheels in his new species *Trochodota maculata* had discontinuous series of teeth. The 1921 illustration of a wheel suggests that Clark was viewing the wheel from the side on which the continuous series is not evident as the series is partly obscured by the spokes.

No species of *Rowedota* gen. nov. occurs in Antarctica. The new genus is erected within this revision of genera of Taeniogyrinae.

Scoliorhapis Clark, 1946

Table 3

Scoliodota Heding, 1928: 277, 278, 319 (junior homonym of *Scoliodota* H. L. Clark, 1908).

Scoliorhapis H. L. Clark, 1946: 461.—Rowe (in Rowe and Gates), 1995: 267.—Smirnov, 1998: 519.—Kerr, 2001: 57.—O'Loughlin and VandenSpiegel, 2007: 53.

Scoliodotella Oguro, 1961: 2–3.

Diagnosis (emended from H. L. Clark 1946). Taeniogyrinae with 10 or 12 peltato-digitate tentacles, each with up to 8 pairs of digits; single polian vesicle; ciliated funnels present; body wall ossicles sigmoid hooks only, hooks scattered or some clustering or alignment; lacking wheels in body wall; tentacle ossicles bracket-shaped or rods.

Type species. Scoliodota theeli Heding, 1928.

Type locality. Australia, New South Wales, Port Jackson.

Other species. Scoliorhapis biopearli sp. nov. (Scotia Sea, S Shetland Is, 1544 m); *Scoliodota lindbergi* Djakonov (in Djakonov et al.), 1958 (Sea of Okhotsk, South Sakhalin and South Kurile Is, 8–22 m); *Scoliorhapis massini* sp. nov. (Scotia Sea, Shag Rocks, 206 m); *Scoliodotella uchidai* Oguro, 1961 (Cape Aikappu, Japan, shallows).

Remarks. The significant emendation to the diagnosis by H. L. Clark (1946) is the inclusion of species that have 12 tentacles. This is in response to *Scoliorhapis massini* sp nov. (below) having 12 tentacles.

Oguro (1961) erected his new genus *Scoliodotella* for chiridotid specimens with sigmoid hooks but no wheels in the body wall. He considered referring his new species to *Scoliodota* H. L. Clark, 1908, unaware that H. L. Clark had rejected *Scoliodota* and erected the genus *Scoliorhapis*. Oguro did not refer his new species to *Scoliodota* because the hooks were not grouped into papillae. We reject clustering of ossicles as a sound generic diagnostic character, and consider *Scoliodotella* to be a junior synonym of *Scoliorhapis*.

Chiridota japonica Marenzeller, 1881 was erected for material from Japan. The species was poorly described. Théel (1886a) referred damaged specimens from Australia (New South Wales) to *Chiridota japonica* Marenzeller. *Scoliodota* H. L. Clark, 1908 was erected as a new monotypic genus for *Chiridota japonica* Marenzeller from Japan and the Théel material from New South Wales on the basis of hook ossicles only in the body wall. But Clark (1908) commented that the

Table 3. Specimen and ossicle sizes for some species of Taeniogyrinae.

Selected species of *Scoliorhapis*, *Sigmodota* and *Taeniogyrus*	Locality (this work) or authors	Maximum preserved length	Wheel diameter µm	Hook length µm	Tentacle rod length µm	Tentacle number
Scoliorhapis species						
Soliorhapis theeli (type species)	Heding 1928	no data	absent	100–140	106	10
Scoliorhapis biopearli sp. nov.	S Shetland Is (this work)	6 mm	absent	168–184	112–120	10
Scoliorhapis massini sp. nov.	Shag Rocks (this work)	20 mm	absent	88–104	up to 80	12
Scoliorhapis ? massini sp. nov.	Falkland Is (this work)	50 mm	absent	120–176	120–160	12
Sigmodota species						
Sigmodota contorta (type species for *Sigmodota*)	Ludwig 1875	45 mm	94	140–160	no data	12
	Ludwig 1898	45 mm	44–130	170–200	156–182	12
	H. L. Clark 1921	no data	42–130	170–210	170	12
	Ekman 1925	44 mm	45–120	140–170	no data	no data
	Pawson 1964	50 mm	42–130	140–200	170	12
	Massin & Hétérier 2004	45 mm	35–100	160–250	140–170	12
	Bouvet I. (this work)	10 mm	40–88	224–240	120–128	12
	Falkland Is (this work)	40 mm	40–128	136–200	80–184	12
	S Georgia (this work)	45 mm	48–96	192–248	80–144	12
	S Georgia (this work)	8 mm	56–72	no data	up to 128	12
	S Orkney Is (this work)	9 mm	40–88	152–184	96–112	12
	S Shetland Is (this work)	15 mm	56–104	168–176	96–112	12
	Magellanic (this work)	40 mm	up to 136	up to 208	up to 184	12
	Heard I. (this work)	no data	88–104	192–208	104–168	12
	Summary	**50 mm**	**35–136**	**136–250**	**80–184**	**12**
Sigmodota dubia	Fisher 1907	60 mm	90–175	185–230	no data	12
Sigmodota magnibacula	Massin & Hétérier 2004	72 mm	100–200	160–180	170–280	12
	S Orkney Is (this work)	70 mm	112–160	192–216	256–296	12
	S Orkney Is (this work)	15 mm	56–120	128–176	176–216	12
	Ross Sea (this work)	25 mm	96–136	152–200	192–240	12
	Ross Sea (this work)	73 mm	110–140	170–190	200–270	12
	Wilkes Land (this work)	60 mm	up to 104	up to 192	up to 272	12
	Prydz Bay (this work)	105 mm	80–186	176–192	184–320	12
	Summary	**105 mm**	**56–200**	**128–216**	**170–320**	**12**
Taeniogyrus species						
Taeniogyrus antarcticus	Heding 1931	no data	no data	172–200	83–103	10
	S Orkney Is (this work)	15 mm	64–80	200–208	128	10
	S Orkney Is (this work)	7 mm	40–64	120–152	80–104	10
	S Orkney Is (this work)	3 mm	48–72	112–120	128	10
	S Orkney Is (this work)	2 mm	40–56	80–88	80	10
	Shag Rocks (this work)	8 mm	48–64	144–168	no data	10
	Shag Rocks (this work)	1 mm	48–64	64–80	64–72	10
	Summary	**15 mm**	**40–80**	**64–208**	**64–128**	**10**
Taeniogyrus australianus (type species for *Taeniogyrus*)	Australia (this work)	95 mm	48–88	112–136	72–104	10
	Heding 1928	60 mm	70–100	up to 110	110	10
	Summary	**95 mm**	**48–100**	**110–136**	**72–110**	**10**
Taeniogyrus maculatus	H. L. Clark 1921	26 mm	50–100	66–77	about 45	10
	Newcastle (this work)	21 mm	48–104	80–96	56–72	10
	Summary	**26 mm**	**48–104**	**66–96**	**45–72**	**10**
Taeniogyrus prydzi sp. nov.	Prydz Bay (this work)	7 mm	up to 90	232–240	136–144	10
	Prydz Bay (this work)	50 mm	up to 90	256–272	136–152	10
	Summary	**50 mm**	**up to 90**	**232–272**	**136–152**	**10**
Taeniogyrus purpureus	Ludwig 1898	33 mm	165–182	135–156	78–87	10
	Ekman 1925	33 mm	70–180	80–150	no data	no data
	H. L. Clark 1921	no data	154–182	125–150	76–87	no data
	Pawson 1964	100 mm	130–180	120–130	average 78	10
	Magellanic (this work)	15 mm	80–144	120–160	56–120	10
	Summary	**100 mm**	**70–182**	**80–160**	**56–120**	**10**

Marenzeller and Théel materials might represent different species. Ohshima (1913) reported that *Chiridota japonica* von Marenzeller had both hook and wheel ossicles, and belonged to *Trochodota* Ludwig, 1891.

Clark (1921) rejected his own genus *Scoliodota* Clark, 1908 on the grounds that his type species *Chiridota japonica* von Marenzeller belonged to *Trochodota* Ludwig. Heding (1928) stated that Clark (1921) abandoned *Scoliodota* Clark without considering the Théel specimens from New South Wales. Heding (1928) erected a new species for the New South Wales specimens that lacked wheels, and referred them to *Scoliodota* Clark. Heding (1928) nominated his *Scoliodota theeli* Heding, 1928 as the new type for *Scoliodota* Clark, 1908.

Clark (1946) insisted that he selected Japanese material as type for his *Scoliodota*, although that is not explicit in the text (Clark 1908). Clark (1946) rejected Heding's resurrection of *Scoliodota* Clark, and erected a new monotypic genus *Scoliorhapis* Clark, 1946 with type species *Scoliodota theeli* Heding, 1928.

Clark (1921) noted that *Chiridota geminifera* Dendy and Hindle, 1907 had hook ossicles but lacked wheels, but because of the single small and damaged type specimen considered the material to be unreliable for referral to *Scoliodota* Clark. He considered *Chiridota geminifera* Dendy and Hindle to be a junior synonym of *Trochodota dunedinensis* (Parker, 1881).

Scoliorhapis biopearli sp. nov.

Figure 1c; tables 2, 3

Material examined. Holotype. South Shetland Is, 61.61°S 51.22°W, 1544 m, BAS stn EI–EBS–1, NMV F168633.

Diagnosis. Conical form, widest orally, tapered anally, dorsal projecting over ventral orally, 6 mm long; 10 tentacles, number of digits not evident; tentacle ossicles curved bracket-shaped rods with bluntly spinous distal outer edges, 112–120 μm long; body wall ossicles sigmoid hooks only, in close transverse alignment, not clustered, hooks 168–184 μm long.

Colour (preserved). White to translucent.

Distribution. South Shetland Is, 1544 m.

Etymology. Named for the British Antarctic Survey BIOPEARL expedition that collected and documented this specimen.

Remarks. This species is erected for a single, small BAS BIOPEARL specimen with tentacle and body wall ossicles that are eroded but retain distinguishable form and size. The presence of hooks only, and not wheels, in the body wall distinguishes this apodid specimen as a species of *Scoliorhapis* Clark. The distinctive presence of 10 tentacles distinguishes this species from the second new species of *Soliorhapis* Clark from Antarctica described below. *Scoliorhapis biopearli* sp. nov. is distinguished from the type species *Scoliorhapis theeli* (Heding) from eastern Australia by the larger size of the hooks (see Table 3) and transverse arrangement of the hooks in the body wall, and the spinous ends of the bracket-shaped tentacle ossicles.

Scoliorhapis massini sp. nov.

Figures 1d, 9a, b; tables 2, 3

Material examined. Holotype. Scotia Sea, Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, NMV F168635.

Other material. Falkland Is, 50°55'S 59°58'W, 118 m, *Discovery Expedition*, *William Scoresby* stn 756, 10 Oct 1931, NHM 2010.105–109 (5).

Diagnosis. Elongate, thin, 20 mm long; 12 tentacles, 3 pairs of digits; tentacle ossicles slightly curved rods with central swelling and bifurcate ends, up to 80 μm long; body wall ossicles sigmoid hooks only, not clustered, hooks 88–104 μm long.

Colour (preserved). Reddish brown.

Distribution. Scotia Sea, Shag Rocks, 206 m.

Etymology. Named for Dr Claude Massin (Royal Belgian Institute of Natural Sciences), with appreciation of a lifetime of magnificent contribution to holothuroid systematics and in particular here to Antarctic apodid studies.

Remarks. *Scoliorhapis massini* sp. nov. is erected for a single BAS BIOPEARL specimen that is in good condition. It is distinguished from the other two species of *Scoliorhapis* by the presence of 12 tentacles. In addition it has tentacle ossicles that are rods, not bracket-shaped, and the sigmoid hooks and tentacle rods are smaller than in the other two species (see Table 3).

Hérouard (1906) provided the very limited description of 12 tentacles and hook ossicles for specimens from the Bellingshausen Sea that he determined to be *Sigmodota studeri* (Théel). The few diagnostic details would fit *Scoliorhapis massini* sp. nov.

The *Discovery* (1931) Falkland Is specimens occur at a similar depth to the Shag Rocks specimen and are provisionally referred to *Scoliorhapis massini* sp. nov. They are: brown; lack wheels; longer (up to 50 mm long); have 12 tentacles, each with more pairs of digits (up to 6); the ossicles are eroded; the tentacle rods are of similar form but longer (120–160 um long); the hooks longer (120–176 um long). The significantly larger ossicles may reflect the larger specimen sizes or another new species of *Scoliorhapis*.

Sigmodota Studer, 1876

Table 3

Sigmodota Studer, 1876: 454.—Théel, 1886a: 16, 33.—Ludwig, 1898: 73, 81–82.—Östergren, 1898: 117–118.—H. L. Clark, 1908: 121.—Dendy and Hindle, 1907: 113.—Heding, 1928: 277.—Pawson, 1964: 466.—Smirnov, 1998: 519.

Diagnosis. Taeniogyrinid genus with 12 plates in calcareous ring, 12 tentacles, peltato-digitate, 4–7 pairs of digits per tentacle, terminal pair longest; rods in tentacles; chiridotid wheels and sigmoid hooks in body wall; teeth on the inner rim of wheels in continuous series; wheels grouped into papillae, hooks scattered in body wall; no miliary granules in longitudinal muscles; 3–10 polian vesicles; ciliated funnels present.

Type species. Type species fixed here (under Article 70.3.2 of the 1999 edition of the ICZN Code) as *Chiridota contorta* Ludwig, 1875, misidentified as *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 in the original monotypy designation by Studer (1876).

Figure 9. a, b, ossicles from the holotype of *Scoliorhapis massini* sp. nov. (Shag Rocks; NMV F168635). a, SEM of hook from the body wall; b, SEM of rods from a tentacle. c, enhanced colour photo of preserved specimen of *Taeniogyrus australianus* (Stimpson, 1855), showing wheel cluster papillae (large) and hook clusters (small) (27 mm long; Australia, Sydney Harbour, 1968; AM J16377).

Other species. *Taeniogyrus dubius* H. L. Clark, 1921 (as *S. dubia*); *Taeniogyrus magnibaculus* Massin and Hétérier, 2004 (as *S. magnibacula*).

Remarks. We follow Ludwig (1898) and H. L. Clark (1908) and agree that Studer's *Sigmodota purpurea* (Lesson, 1830) is a junior synonym of *Taeniogyrus contortus* (Ludwig, 1875). Studer (1876) erected his new genus *Sigmodota* for the species *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830 because of the presence of sigmoid hooks in apodid specimens from the Kerguelen Is and Magellanic region. He reported 12 tentacles, and ignored the 10 tentacles in the species *Holothuria* (*Fistularia*) *purpurea* Lesson. As understood by Ludwig 1898 and H. L. Clark 1908 and as argued above by us in "Relevant history of species misidentification" the material that Studer examined had 12 tentacles, hooks and wheels.

H. L. Clark (1908) judged *Sigmodota* Studer to be a junior synonym of *Taeniogyrus* Semper, 1867, which he diagnosed as having: 10 or 12 peltato-digitate tentacles; 1 or several polian vesicles; ciliated funnels not in stalked clusters; wheels in papillae; large sigmoid hooks scattered in body wall; lacking miliary granules. He included two species: *Taeniogyrus australianus* (Stimpson, 1855), with 10 tentacles, hooks in papillae, single polian vesicle; and *Taeniogyrus contortus* (Ludwig, 1875), with 12 tentacles, hooks scattered, 6 or 7 polian vesicles.

As discussed above in "Ossicle clusters in generic diagnosis" we reject ossicle aggregation in the body wall as a generic diagnostic character, and judge that tentacle number is a good generic character. Thus we raise *Sigmodota* Studer out of synonymy with *Taeniogyrus* Semper, 1867 on the basis of the type species *Chiridota contorta* Ludwig having 12 tentacles and the type species of *Taeniogyrus*, *Chiridota australiana* Stimpson, having 10.

We examined specimens of *Sigmodota contorta* (Ludwig) and *Sigmodota magnibacula* (Massin and Hétérier) and found that there were consistently 12 subequal plates in the calcareous ring. Plates were fused, and joined beneath the tentacle bases attached to the outside face of the ring. Each plate had a low anterior projection and a shallow concave posterior indentation.

Sigmodota contorta (Ludwig, 1875)

Figure 10; tables 2, 3

Chiridota contorta Ludwig, 1875: 80–81, pl. 6, figs 6a–c.—Lampert, 1885: 234.—Théel, 1886a: 16, 33, pl. 2 fig. 2.—Théel, 1886b: 20.—Lampert, 1889: 853–854.—Ludwig, 1891: 359.—Östergren, 1897: 154.—Ludwig, 1897: 217–219.—Ludwig, 1898: 73–83, pl. 3 figs 37–42.—Perrier, 1905: 77–78.

Sigmodota purpurea.—Studer, 1876: 454.—Studer, 1879: 123.

Chiridota purpurea.—Bell, 1881: 101.—Lampert, 1885: 236.—Lampert, 1886: 18–21, figs 17–20.—Ludwig, 1886: 29, 30.

Chiridota studeri Théel, 1886a: 33.—Lampert in Studer, 1889: 163, 283, 285, 308.

Sigmodota contorta.—Östergren, 1898: 118.—Sluiter, 1901: 134.

Sigmodota studeri.—Hérouard, 1906: 15.

Taeniogyrus contortus.—H. L. Clark, 1908: 121–123, pl. 7 figs 8–13.—H. L. Clark, 1921: 165.—Ekman, 1925: 147–148.—Ekman, 1927: 416–417 (part *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Heding, 1928: 311, fig. 66(1–9).—Deichman, 1947: 348–349.—Pawson, 1964: 466, 467.—Pawson, 1969a: 126, 141.—Pawson, 1969b: 38, map 6.—Pawson, 1971: 289, figs 1, 2.—Arnaud, 1974: 585.—Hernandez, 1981: 164, figs 1k, l, 4d, e.—Gutt, 1988: 24 (part if not all *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Gutt, 1991: 324 (part if not all *Sigmodota magnibacula* (Massin and Hétérier, 2004)).—Massin, 1992: 311.—Branch et al., 1993: 40, 56, 61, 65.—O'Loughlin, 2002: 298, 300, 301, tables 1, 2 (part *Sigmodota magnibacula* (Massin and Hétérier, 2004); see material examined).—Massin and Hétérier, 2004: 442, 443, table 1.—O'Loughlin, 2009: 2, table 1.

Taeniogyrus contortus antarcticus.—Panning, 1936: 17, 18, fig. 8.—Pawson, 1969a: 141. (non *Taeniogyrus antarcticus* Heding, 1931)

Chiridota pisanii.—O'Loughlin, 2002: 298, tables 1, 4 (= *Sigmodota contorta*; non *Chiridota pisanii* Ludwig, 1886).

Material examined. South America, Argentina, Santa Cruz, east of Grande Bay, *Albatross* Stn 2771, 51°34'S 68°00'W, 91 m, 1888, USNM 19826 (3); Chile, Inutil Bay, 53°35'S 69°45'W, 37–46 m, 1969, USNM E33679 (13); 53°34'S 69°59'W, 82–91 m, 1970, USNM E33715 (9).

Falkland Is, 52°10'S 64°56'W, 150 m, *Discovery Expedition*, *William Scoresby* stn 816, 14 Jan 1932, NHM 2010.55–62 (8); 54°00'S 64°58'W, 118 m, *Discovery Expedition*, *William Scoresby* stn 88, 6 Apr 1927, NHM 2010.63–68 (6); E Falkland Is, 75 m, *Discovery Expedition*, *William Scoresby* stn 84, 24 Mar 1927, NHM 2010.69–70 (2); 296 m, *Discovery Expedition*, *William Scoresby* stn 773, 31 Oct 1931, NHM 2010.71–74 (4); Saldanka Bay, *Discovery Expedition*, *William Scoresby* Marine Station 82, 6 Sep 1926, NHM 2010.75–84 (many).

Antarctic Ocean, Bouvet I., ICEFISH 2004 stn 80–BT42, 54.40°S 03.48°W, 159 m, NMV F104990 (1).

South Georgia, ICEFISH 2004 stn 38–BT18, 54.00°S 37.66°W, 46 m, NMV F104799 (1); 18–25 m, *Discovery Expedition*, *William Scoresby* stn 25, 17 Dec 1926, NHM 2010.85–94 (11); RBINS IG 31 459 (1, SEM); 2 m, *Discovery Expedition*, *William Scoresby* stn 56, 14 Jan 1927, NHM 2010.95–96 (2); 179–235 m, *Discovery Expedition*, stn 39, 25 Mar 1926, NHM 2010.97–98 (2); 0–100 m, *Discovery Expedition*, stn 126, 19 Dec 1926, NHM 2010.99 (1); 26–83 m, *Discovery Expedition*, *William Scoresby* stn 62, 19 Jan 1927, NHM 2010.100–103 (4); Leith Harbour, 22–55 m, *Discovery Expedition*, stn 1941, 29 Dec 1936, NHM 2010.104 (1).

S Shetland Is, 61.34°S 55.20°W, 204 m, 3 Dec 2006, BAS stn EI–EBS–4, NMV F168628 (1).

S Orkney Is, 53.60°S 37.90°W, 503 m, BAS stn SG–EBS–3, NMV F168632 (1); NMV F168642 (2 specimens as tissues); NHM 2010.35–47 (13); RBINS IG 31 459 (2, SEM figures).

Indian Ocean, Heard I., ANARE, 52°41'–53°13'S 72°56'–73°41'E, 120–228 m, NMV F84977 (1), F84978 (1), F84979 (1); Kerguelen Is, 49°33'S 69°49'E, 20 m, SAM K2384 (1); BANZARE stn 12, 49°28'S 70°04'E, 4–5 m, 1929, SAM K1839 (1); BANZARE stn 49, 49°30'S 69°48'E, 2–20 m, 1930, SAM K1840 (1).

Diagnosis. Sigmodotid species up to 50 mm long (preserved); tentacles 12, 4–7 pairs of digits, longest distally; wheels in distinct papillae, scattered over interradii, more numerous dorsally and anteriorly, wheels 35–136 μm diameter; hooks scattered, frequently about twice the size of the wheels, 136–250 μm long; tentacle rods 80–184 μm long, significantly shorter than hooks; up to 7 unequal polian vesicles; gonad tubules dichotomously branched.

Type locality. Unknown (3 specimens).

Colour (preserved). Predominantly dark reddish-brown, rarely grey and translucent.

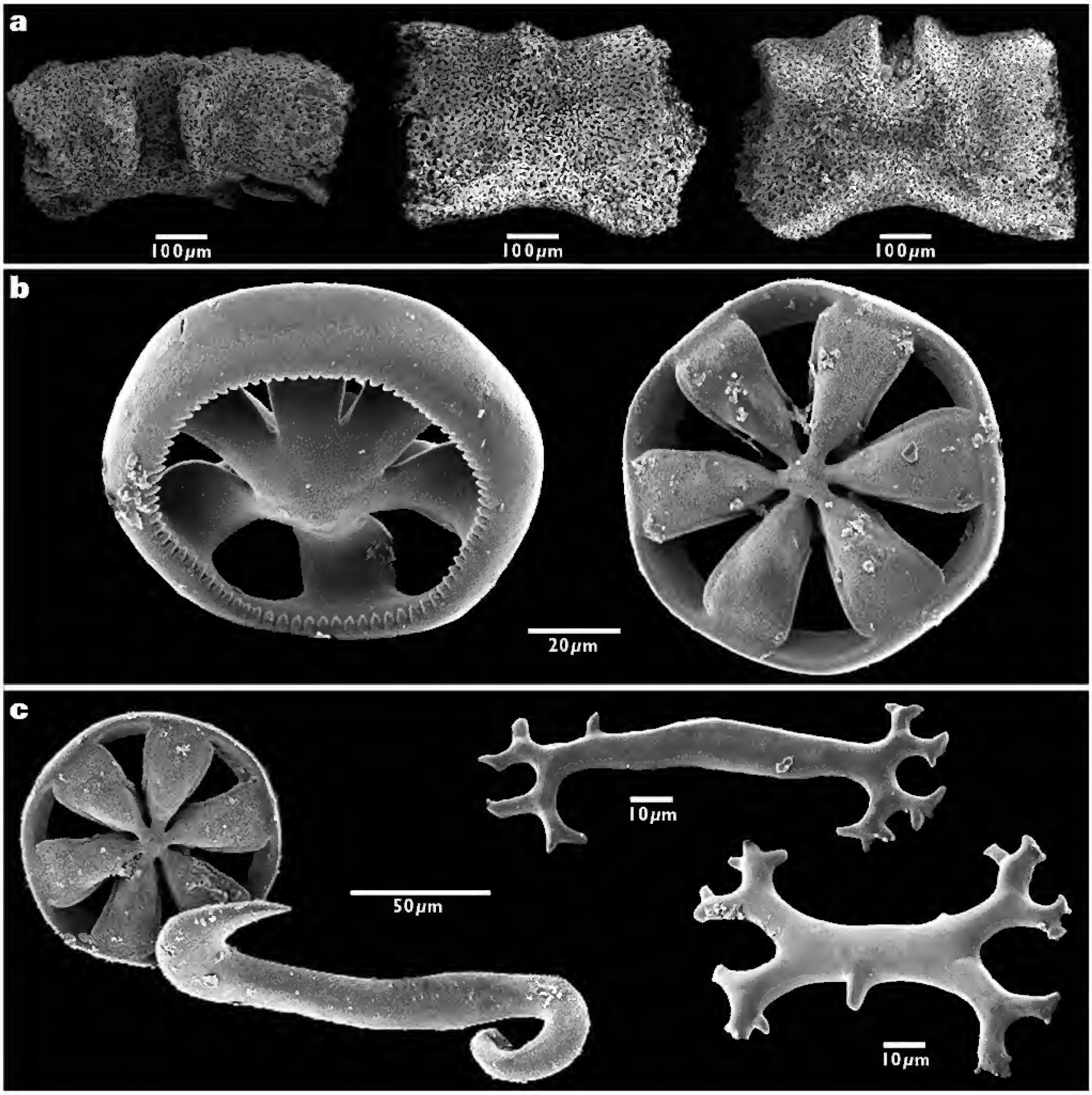

Figure 10. SEM images for specimens of *Sigmodota contorta* (Ludwig, 1875). a, plates from calcareous ring (specimen from *Discovery Expedition*, *William Scoresby* stn 25, South Georgia, 18–27 m, RBINS IG 31 459). b, c, ossicles from S Shetland Is specimen (NMV F168628); b, wheels from body wall; c, hook and wheel from body wall (left), rods from tentacle (right).

Distribution. Western Antarctica, Bouvet I., 159 m; South Georgia, 46 m; S Shetland Is, 204 m; S Orkney Is, 503 m.

South America, south of 42° in the west, S of 47°S in the east (Pawson 1969a).

Indian Ocean, Heard I., 120–228 m; Kerguelen Is, 2–20 m, 116 m (Lampert 1889); Marion I., 125–132 m (Branch et al. 1993).

Java Sea, 82 m (Sluiter 1901).

Remarks. Specimens of the species *Sigmodota contorta* (Ludwig) have been subjected to many misidentifications, as discussed at the beginning of this work and as is evident in the synonymy above.

Sluiter (1901) determined 3 *Siboga* specimens (stn 319) up to 10 mm long from the Java Sea at 82 m as *Sigmodota contorta* (Ludwig).

Hérouard (1906) provided the very limited description of 12 tentacles and hook ossicles for specimens from the Bellingshausen Sea that he determined to be *Sigmodota studeri* (Théel). The few diagnostic details would fit *Scoliorhapis massini* sp. nov. (above).

Panning (1936) examined specimens from South Georgia that he judged to be *Taeniogyrus antarcticus* Heding, 1931. He found the specimens close to *Taeniogyrus contortus* (Ludwig), and made the Heding species a subspecies (*Taeniogyrus contortus antarcticus* Heding). Based on tentacle number (12) and ossicle sizes, we judge that Panning (1936) was in fact examining specimens of *Sigmodota contorta* (Ludwig).

Massin and Hétérier (2004) erected their species *Taeniogyrus magnibaculus* for specimens from the Weddell Sea subsequent to the work of Cherbonnier (1974), Gutt (1988, 1991), and O'Loughlin (2002) who reported *Taeniogyrus contortus* (Ludwig) from the regions of Terre Adélie, the Weddell Sea and Prydz Bay respectively. The Prydz Bay material has been redetermined as *Taeniogyrus magnibaculus*, which has also been found by us in the Ross Sea and off Wilkes Land. *Taeniogyrus contortus* (Ludwig) has not been found on coastal eastern Antarctica, and it is anticipated that the Cherbonnier reference was to *Taeniogyrus magnibaculus* and this synonymy is given below. Likewise Gutt (1988, 1991) reported *Taeniogyrus contortus* from the Weddell Sea. We anticipate that some or possibly all of his material was *Taeniogyrus magnibaculus*. *Taeniogyrus contortus* and *Taeniogyrus magnibaculus* are generally allopatric, except in the South Orkney Is.

The mistaken identification by O'Loughlin (2002) of Heard I. specimens as *Chiridota pisanii* Ludwig, 1886 was corrected by Bohn in Altnöder et al. (2007), and discussed by O'Loughlin (2009). The specimens are listed here as *Taeniogyrus contortus* (Ludwig).

Sigmodota dubia (H. L. Clark, 1921)

Table 3

Taeniogyrus species Fisher, 1907: 735, pl. 82 fig. 2.

Taeniogyrus dubius H. L. Clark, 1921: 166 (key and note).—Heding, 1928: 311.—Massin and Hétérier, 2004: 442, 443, table 1.

Distribution. Hawaiian Is, Oahu I., 403–470 m.

Remarks. Fisher (1907) reported 12 tentacles, 10 polian vesicles of unequal size, and aggregations of wheels. His specimen and ossicle meaurements are given in Table 3. H. L. Clark (1921) named the species. Fisher (1907) noted that this species was close to *Taeniogyrus contortus* (Ludwig), and distinguished it by the larger number of polian vesicles (10, unequal) and size and form of the sigmoid ossicles. We found the wheels of *Sigmodota dubia* as reported by Fisher (1907) to be significantly larger than our measurements for *Sigmodota contorta*, but the hooks not significantly smaller, as was judged by Fisher (1907) (see Table 3).

Sigmodota magnibacula (Massin and Hétérier, 2004)

Figure 1e, 11; tables 2, 3

Taeniogyrus contortus.—Ekman, 1927: 416–417.—Cherbonnier, 1974: 610.—Gutt, 1988: 24.—Gutt, 1991: 324. (all or part probably non *Taeniogyrus contortus* (Ludwig, 1875))

Taeniogyrus cf. *contortus*.—O'Loughlin et al., 1994: 553, 554.

Taeniogyrus magnibaculus Massin and Heterier, 2004: 441–444, figs 1, 2, table 1.

Material examined. Scotia Sea, South Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB–EBS–4, 2006, NMV F168629 (1); NMV F168639 (1 specimen as tissue sample MOL AF 798); NHM 2010.1–4 (4); RBINS IG 31 459 (1, SEM figures); 60°50'S 44°30'W, 172 m, US AMLR 2009 stn 16–31, NMV F168840 (13); 61°13'S 45°56'W, 240 m, US AMLR stn 41–46, NMV F168841 (8).

Eastern Antarctica, Ross Sea, McMurdo Sound, 366 m, *Terra Nova* stn 348, 13 Feb 1912, NHM 1932.8.11.216–217 (2); NHM 1932.8.11.218 (1); Cape Adare, 71°53'S 170°11'E, 220 m, BIOROSS stn TAN0402/94, NIWA 61060 (2); Ross Sea, 74°43'S 164°08'E, 140 m, MNA 2440 (1); 74°43'S 164°07'E, 120 m, MNA 2446 (10); 74°45'S 164°15'E, 219 m, MNA 2462 (1); IPY–CAML stn TAN0802/26, 74°58'S 170°27'E, 285 m, NIWA 35724 (4); stn TAN0802/31, 74°59'S 170°27'E, 283 m, NIWA 35776 (1).

Wilkes Land, 66°18'S 110°32'E, 101 m, USARP 1961, USNM E33725 (25).

Prydz Bay, ANARE 1987, stn 51, 525 m, NMV F76847 (1); stn 22, 165 m, NMV F168862 (1); stn 38, 312 m, NMV F168863 (3); N end of Fram Bank, 67°05'S 68°59'E, 216 m, ANARE AA93–131, NMV F69100 (2).

MacRobertson Shelf, 67°16'S 65°25'E, 121 m, ANARE AA93–127, NMV F68691 (20); 66°55'S 62°32'E, 113 m, AA93–124, NMV F69099 (2); Mawson Base, 8 m, ANARE 1972, NMV F168839 (1).

Diagnosis. Sigmodotid species up to 105 mm long (preserved); 12 peltato-digitate tentacles, 6 pairs of digits per tentacle, apical pair largest, decreasing in size towards base of tentacle trunk; rows of interradial off-white papillae comprising clusters of chiridotid wheels; wheels 56–200 μm diameter; hooks scattered in body wall, 128–216 μm long, blunt spines on outer surface of hook variably present and of variable size; tentacle rods irregularly straight, slightly swollen mid-rod, tapered, short branches distally, 170–320 μm long; calcareous ring and ossicles sometimes absent in largest specimens; 3 polian vesicles.

Colour (preserved). Body wall and tentacles dark red-brown to violet-brown epidermally, dark grey underneath.

Distribution. Antarctic, Weddell Sea, 72°29'S 26°57'W, 226 m (Massin and Hétérier 2004); South Orkney Is, 172–240 m;

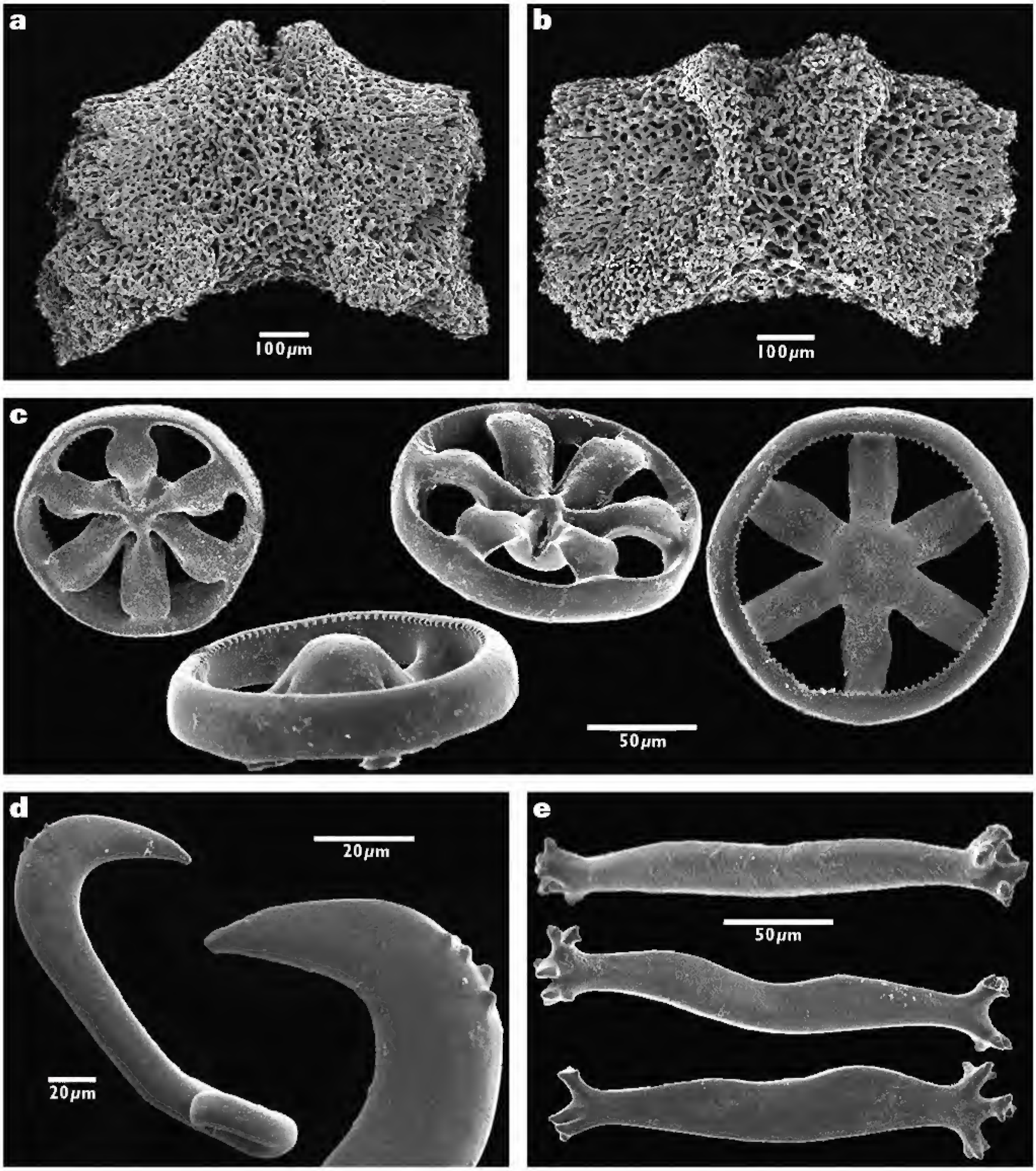

Figure 11. SEM images for specimens of *Sigmodota magnibacula* (Massin and Hétérier, 2004). a, b, plates from calcareous ring (Prydz Bay; RBINS IG 31 459 ex NMV F68691); c, wheels from body wall (S Orkney Is; RBINS IG 31 459 ex NMV F168842); d, hooks from body wall (S Orkney Is; RBINS IG 31 459); e, rods from tentacles (S Orkney Is; RBINS IG 31 459 ex NMV F168842).

Ross Sea, 120–366 m; Terre Adélie, 170–250 m (Cherbonnier 1974); Wilkes Land, 101 m; Prydz Bay, 165–525 m; MacRobertson Shelf, 8–121 m.

Remarks. As can be seen in Table 3 the maximum size of specimens, and length and form of the tentacle rods, are good diagnostic characters for *Sigmodota magnibacula* (Massin and Hétérier). Diameter of wheels and length of hooks are comparable, but tentacle rods much larger. As discussed above in the Remarks under *Sigmodota contorta* (Ludwig), the eastern Antarctic material of Cherbonnier (1974) is judged to be *Sigmodota magnibacula*, as is some or all of the Weddell Sea material of Gutt (1988, 1991). In discussing *Taeniogyrus contortus* (Ludwig) from the "Winterstation", Ekman (1927) made mention of what is probably this species. Massin and Hétérier (2004) noted that this species was "living on the spines of cidarid echinoids". We have not seen evidence of such an association. The US AMLR specimens were found inside Demospongiae.

Taeniogyrus **Semper, 1867**

Table 3

Taeniogyrus Semper, 1867: 23.—Smirnov, 1998: 519.

(For synonymies see Ludwig 1898 and Pawson 1964).

Trochodota Ludwig, 1891: 358.—Pawson, 1968: 24.—Pawson, 1970: 46.—Smirnov, 1998: 519.

(For synonymies see Ludwig 1898 and Pawson 1964).

Type species of *Taeniogyrus* Semper, 1867. *Chiridota australiana* Stimpson, 1855 (monotypy).

Type species of *Trochodota* Ludwig, 1891. Rowe (in Rowe and Gates 1995) proposed that "a case needs to be put to the ICZN to establish *Holothuria (Fistularia) purpurea* Lesson, 1830 as type species of *Trochodota* Ludwig, 1891. Type species: *Chiridota studeri* Théel, 1886, sensu Ludwig, 1891=*Holothuria (Fistularia) purpurea* Lesson, 1830 (not Théel, 1886=*Taeniogyrus contortus* (Ludwig, 1875)) by subsequent designation, Rowe, F. W. E., this work." The type species proposed by Rowe is fixed here (under Article 69.2.4 of the 1999 edition of the ICZN Code) as *Holothuria (Fistularia) purpurea* Lesson, 1830, misidentified as *Chiridota studeri* Théel, 1886a in the original inclusion of two species in his new genus by Ludwig (1891).

Other included species. *Taeniogyrus antarcticus* Heding, 1931; *Chiridota benhami* Dendy, 1909; *Taeniogyrus cidaridis* Ohshima, 1915; *Taeniogyrus clavus* Heding, 1928; *Taeniogyrus dayi* Cherbonnier, 1952; *Taeniogyrus dendyi* Mortensen, 1925; *Trochodota diasema* H. L. Clark, 1921 (as *T. diasemus*); *Chiridota dunedinensis* Parker, 1881; *Taeniogyrus heterosigmus* Heding, 1931; *Trochodota inexpectata* Smirnov, 1989 (as *T. inexpectatus*); *Chiridota japonica* von Mareneller, 1881 (as *T. japonicus*); *Taeniogyrus keiensis* Heding, 1928; *Trochodota maculata* H. L. Clark, 1921 (as *T. maculatus*); *Trochodota neocaladonica* Smirnov, 1997 (as *T. neocaladonicus*); *Taeniogyrus papillis* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Taeniogyrus prydzi* sp. nov.; *Holothuria (Fistularia) purpurea* Lesson, 1830 (as *T. purpureus*); *Trochodota roebucki* Joshua, 1914; *Trochodota rosea* Ohshima, 1914 (as *T. roseus*); *Taeniogyrus tantulus* O'Loughlin, 2007 (in O'Loughlin and VandenSpiegel); *Chiridota venusta* Semon, 1887 (as *T. venustus*).

Diagnosis. Taeniogyrinid genus with 10 peltato-digitate tentacles; 4–8 pairs of digits, terminal pair longest; rods in tentacles; chiridotid wheels and sigmoid hooks in body wall; teeth on the inner rim of wheels in continuous series; wheels and hooks variably grouped or scattered in body wall; no miliary granules in longitudinal muscles; 1–12 polian vesicles; ciliated funnels present.

Remarks. The succession of authors who have expressed dissatisfaction with the genera *Taeniogyrus* Semper and *Trochodota* Ludwig is mentioned in the Introduction. As discussed at the beginning of this paper and stated in the Remarks under *Sigmodota* we reject ossicle aggregation in the body wall as a generic diagnostic character, and judge that tentacle number is a good generic character. We thus raise *Sigmodota* Studer (taeniogyrinid species with 12 tentacles) out of synonymy with *Taeniogyrus* Semper (10 tentacles), and synonymise *Trochodota* Ludwig with *Taeniogyrus* Semper (taeniogyrinids with 10 tentacles).

Taeniogyrus antarcticus **Heding, 1931**

Figures 1f, 12; tables 2, 3

Taeniogyrus antarcticus Heding, 1931: 685–691, fig. 15(1–12).—Pawson, 1969a: 141.—Massin and Hétérier, 2004: 442–443, table 1.

Material examined. Western Antarctica, Scotia Sea, S Orkney Is, 60.82°S 46.49°W, 216 m, BAS stn PB–EBS–4, 18 Mar 2006, NMV F168630 (1); NMV F168640 (2 as tissue samples, codes MOL AF799, 800); NMV F168641 (2 as tissue samples, codes MOL AF801, 802); NHM 2010.5–14 (10); NHM 2010.15–34 (20); RBINS IG 31 459 (2 whole, SEM figures).

Shag Rocks, 53.63°S 40.91°W, 206 m, BAS stn SR–EBS–4, 11 Apr 2006, NMV F168636 (1); RBINS IG 31 459 (1 whole, SEM figures); NHM 2010.51–52 (2).

Diagnosis. Up to 15 mm long; 10 tentacles; 5 pairs of digits, terminal/distal pair longest; 3–9 polian vesicles; few long, thin ciliated funnels with long membranaceous collar, short funnel, and distinct peduncle; chiridotid wheels 40–80 μm diameter (no data in Heding 1931; 40–80 μm, S Orkney Is; 48–64 μm, Shag Rocks), wheels in a few small clusters dorsally; hooks scattered in body wall, 64–208 μm long (172–200 μm, Heding 1931 fig. 15; 80–208 μm, S Orkney Is; 64–168 μm, Shag Rocks); tentacle rods straight to slightly bent to bracket-shaped, dichotomously branching ends, rare blunt spines along rods, rare rounded hub in mid-rod, 64–128 μm long (83–103 μm, Heding 1931 fig. 15; 80–128 μm, S Orkney Is; 64–72 μm, Shag Rocks).

Colour (preserved). Pale yellow-brown.

Distribution. Western Antarctica, Scotia Sea, South Orkney Is, South Georgia, Shag Rocks, 206–216 m (0–15 m for South Georgia in Massin and Hétérier 2004).

Remarks. Heding (1931) erected his new species for many specimens from South Georgia, by distinguishing them within a discussion of *Taeniogyrus contortus* (Ludwig). Massin and

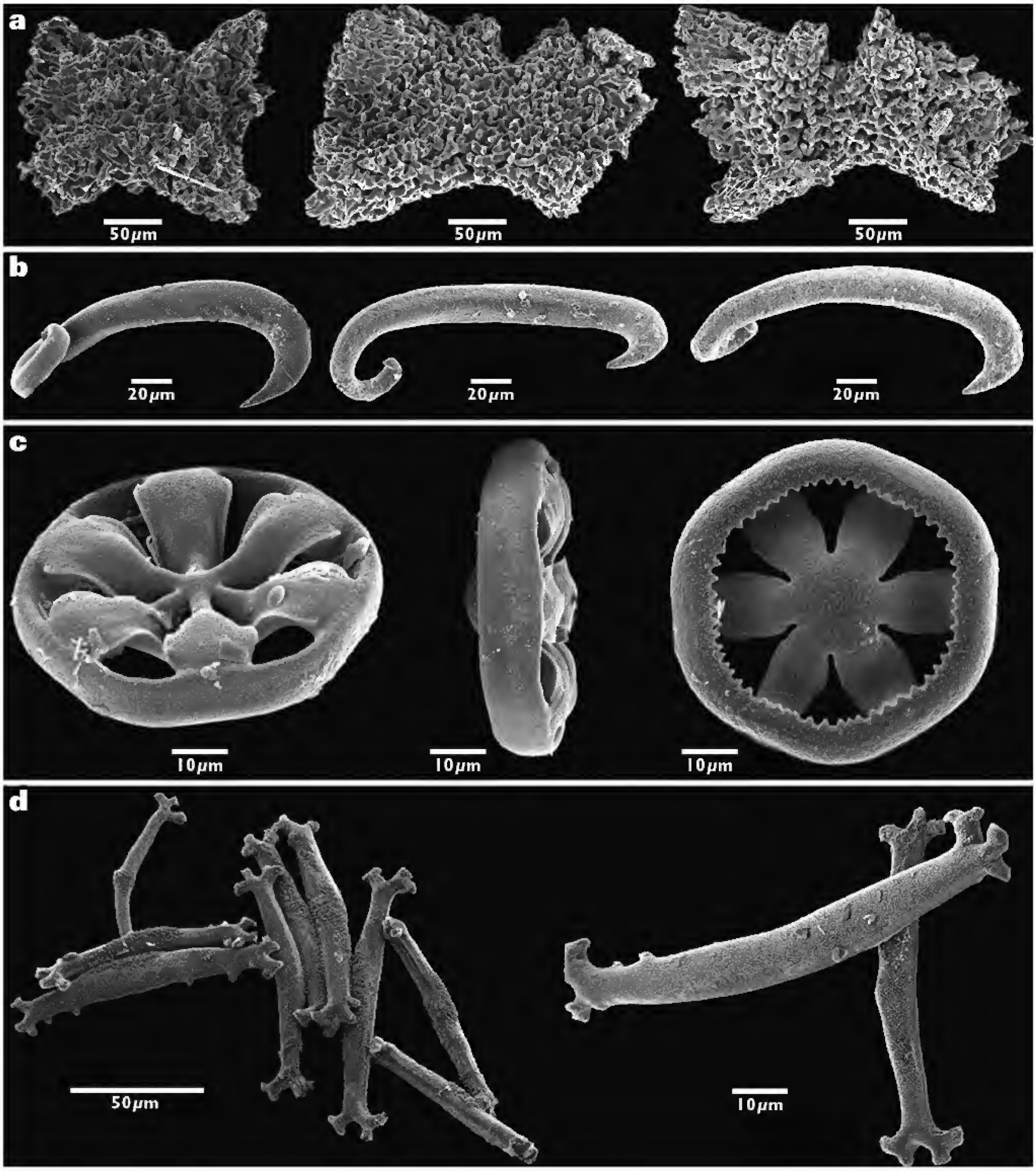

Figure 12. SEM images for specimen of *Taeniogyrus antarcticus* Heding, 1931 (S Orkney Is; RBINS IG 31 459). a, plates from the calcareous ring; b, hooks from the body wall; c, wheels from the body wall; d, rods from the tentacles.

Hétérier (2004 table) listed 12 tentacles for *Taeniogyrus antarcticus* Heding, but in the last sentence of his discussion Heding (1931) noted that *Taeniogyrus contortus* specimens all had 12 tentacles "apart from this example" (referring to his new species *Taeniogyrus antarcticus*).

Panning (1936) considered *Taeniogyrus antarcticus* Heding to be at best a subspecies of *Taeniogyrus contortus* Ludwig. Pawson (1969a) followed Panning (1936). On the basis of tentacle number we disagree. Based on tentacle number and ossicle sizes we judge that the specimens from South Georgia that were examined by Panning (1936) were *Sigmodota contorta* (Ludwig).

There are significant differences in the measurement sizes available for ossicles from different localities in the Scotia Sea, as can be seen in Table 3. The variations may be the result of size of specimen sampled or location of the sample taken from the body wall. Or the variations may indicate cryptic speciation. In this study we found that for this species the limited data available indicate that maximum ossicle size increases with specimen size. The type locality for *Taeniogyrus antarcticus* Heding is South Georgia.

Taeniogyrus antarcticus Heding, 1931 is the sole western Antarctic species of *Taeniogyrus*. A new species of *Taeniogyrus* from eastern Antarctica is described below, with significantly longer sigmoid hooks and a single polian vesicle.

Taeniogyrus australianus (Stimpson, 1855)

Figures 9c, 13; table 3

Chiridota australiana Stimpson, 1855: 386.—Lampert, 1885: 230.—Ludwig, 1898: 82–83.

Taeniogyrus australianus.—Semper, 1867: 23.—H. L. Clark, 1908: 122.—H. L. Clark, 1921: 166.—Heding, 1928: 310, 311, 315–316, fig. 67(9–16).—H. L. Clark, 1946: 459.—Rowe (in Rowe and Gates), 1995: 267.

Sigmodota australiana.—Östergren, 1898: 118.

Material examined. Australia, Sydney, Collaroy, Long Reef, in sand, AM J20086 (2); same lot, RBINS IG 31 459 (1 whole for SEM images); AM J12542 (1); Middle Harbour, AM J16377 (1); Lord Howe I., AM J16373 (1); Heron I., AM J19570 (11).

Diagnosis. Taeniogyrid species up to 95 mm long (preserved); 10 peltato-digitate tentacles, 6–7 pairs of digits per tentacle, longest distally; single madreporite at oral end of dorsal mesentery, mushroom-like head; single ventral elongate sac-like polian vesicle; 2 series of crowded ciliated funnels, on left edge of left ventral radial muscle, and right edge of mid-ventral radial muscle; chiridotid wheels in large to small discrete papillae, wheels 48–88 μm diameter; sigmoid hooks in small papillae, not scattered, hooks 120–136 μm long; tentacle rods thickened centrally, slightly curved, bifurcate ends, 72–104 μm long.

Distribution. Eastern Australia (Mooloolaba in Queensland to Ulladulla in New South Wales; Great Barrier Reef; Heron I.; Lord Howe I.; 0–15 m (Rowe and Gates 1995).

Remarks. *Taeniogyrus australianus* (Stimpson) is not an Antarctic apodid species but has not been fully illustrated in previous works and is included here as it is the type species of the revised genus *Taeniogyrus*, and its identity was confused by Théel (1886a). He described two specimens of *Chiridota australiana* Stimpson from Port William (with uncertainty whether New Zealand or Falkland Is) that were 35 mm long, with 10 tentacles, each with 4 pairs of digits, a single polian vesicle, wheels 140 μm diameter with no evidence of clustering, hooks 140 μm long. We agree with Ludwig (1898) that this evidence points to *Taeniogyrus purpureus* (Lesson) and the Falkland Is.

Taeniogyrus maculatus (H. L. Clark, 1921)

Figure 14; table 3

Trochodota maculata H. L. Clark, 1921: 163, pl. 36 figs 14–21.—H. L. Clark, 1946: 460.—Rowe, 1976: 203–205, table 1.—Rowe (in Rowe and Gates) 1995: 268.—Smirnov, 1997: 16.

Material examined. E Australia, New South Wales, Newcastle, Swansea Channel, 3 m, 30 Aug 1988, AM J21895 (9); same lot, RBINS IG 31 459 (1 whole for SEM images).

Diagnosis. Up to 21 mm long (preserved; 26 mm long in Clark 1921); body wall papillate, semi-translucent; tentacles 10, 3 pairs of digits (4–5 in Clark 1921); curved to slightly bracket-shaped tentacle rods; wheels with 6 spokes, spokes broad at rim, narrow at hub, teeth on inner rim of wheels in continuous series; sigmoid hooks with fine spinelets on outer surface of projecting pointed hook, hooks scattered in body wall (hooks in small groups and scattered in Clark 1921); ciliated funnels along base of mid-dorsal mesentery; single sac-like polian vesicle; gonad comprises 2 elongate sacs (ossicle measurements in Table 3).

Colour (preserved). Pale to dark reddish-brown. Colour live is pink with numerous minute dark spots (Clark 1921).

Type locality. N Australia, Torres Strait, Murray Is, Mer, reef flat.

Distribution. Tropical Australia, 0–20 m (Rowe in Rowe and Gates 1995).

Remarks. *Taeniogyrus maculatus* (H. L. Clark) is not an Antarctic apodid species but is included here to clarify its generic assignment. The figure of a wheel in H. L. Clark (1921) indicates that the wheel was viewed from the outside and the continuity of teeth around the inner rim obscured by the spokes. This led H. L. Clark to wrongly conclude that the distribution of the teeth was discontinuous. Rowe (1976) followed H. L. Clark (1921). In this study all wheels have continuous series of teeth.

Taeniogyrus prydzi sp. nov.

Figure 15; tables 2, 3

Taeniogyrus sp. MoV 2007 O'Loughlin et al., 1994: 553, 554.

Taeniogyrus sp. MoV 2010 O'Loughlin et al., 1994: 553, 554.

Material examined. Holotype. Eastern Antarctica, MacRobertson Shelf, stn ANARE AA 93–124, 66°55'S 62°32'E, 113 m, M. O'Loughlin, NMV F68690.

Paratypes. MacRobertson Shelf, Edge of Nielsen Basin, stn ANARE AA 93–127, 67°16'S 65°25'E, 109–121 m, NMV F69120 (1); NMV F68689 (1, 2 pieces); Prydz Bay, N of Fram Bank, stn ANARE AA 93–142, 66°49'S 70°25'E, 795–830 m, NMV F68688 (3); NMV F76096 (1).

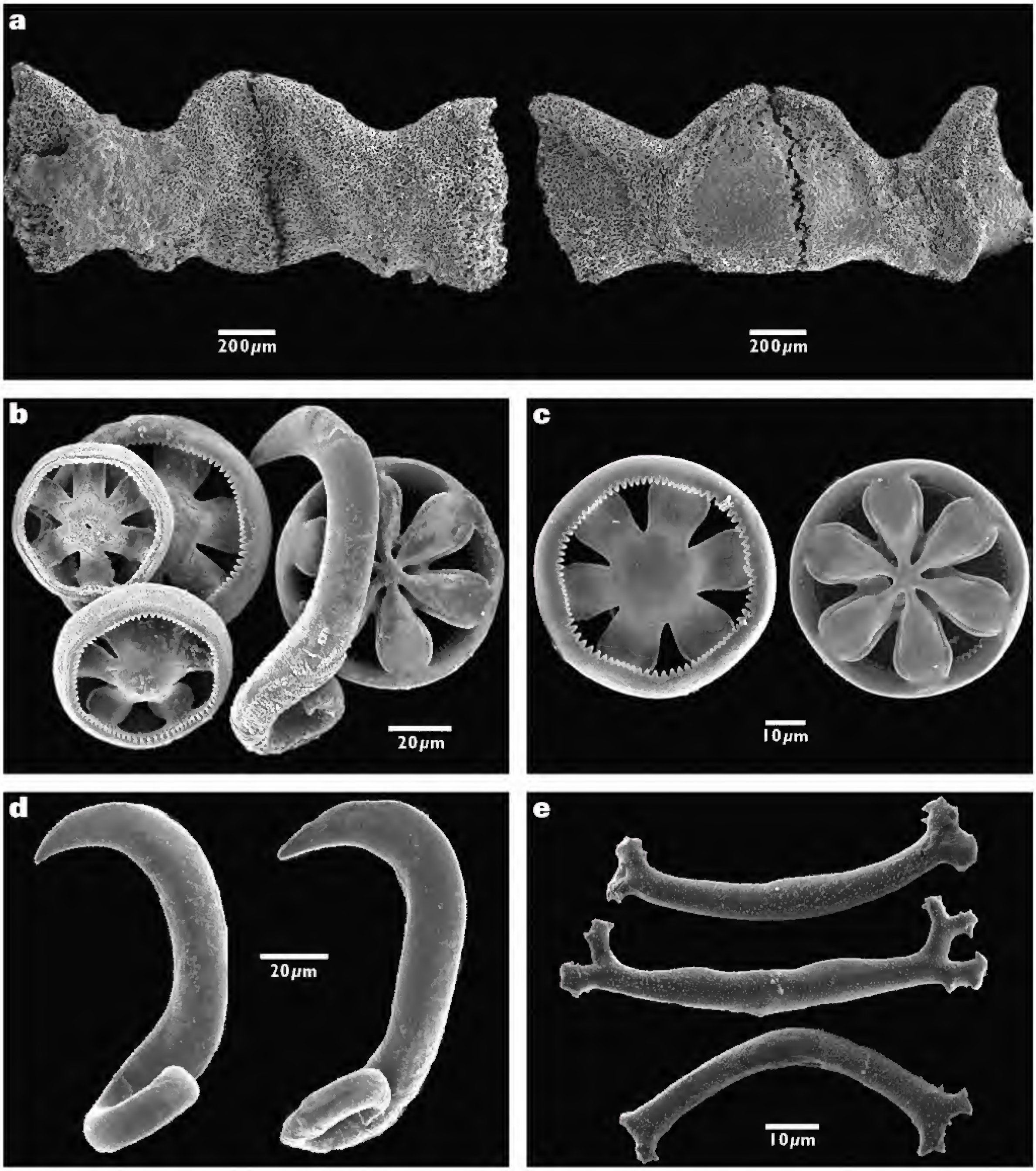

Figure 13. SEM images for specimen of *Taeniogyrus australianus* (Stimpson, 1855) (Long Reef, Collaroy, Sydney; RBINS IG 31 459 ex AM J20086). a, plates from calcareous ring; b, wheels and hook from body wall; c, wheels from body wall; d, hooks from body wall; e, rods from tentacles.

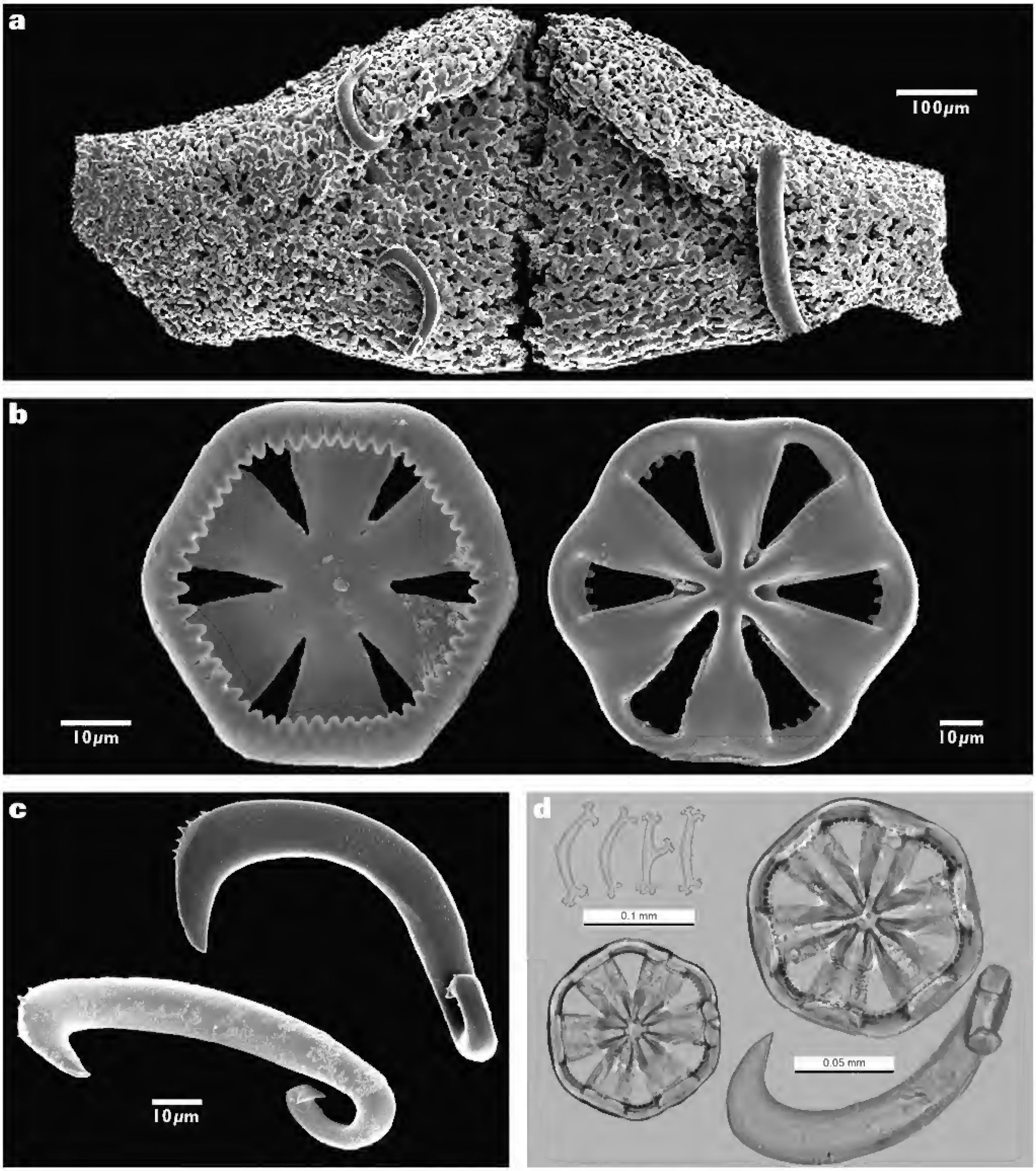

Figure 14. SEM images for specimen of *Taeniogyrus maculatus* (H. L. Clark, 1921) (Swansea Channel, E Australia; RBINS IG 31 459 ex AM J21895). a, calcareous ring plates (with hook contaminants); b, wheels from body wall; c, hooks from body wall. d, montage photographs of ossicles of *Taeniogyrus purpureus* (Lesson, 1830) (Strait of Magellan; USNM 1004241); rods from tentacle, and wheels and hook from body wall.

Diagnosis. Up to 50 mm long; 10 tentacles, 6 pairs of digits per tentacle, digits increasing in length distally; tentacle ossicles rods, thick, predominantly straight, short blunt branches distally, rare centrally, rods 136–152 μm long; chiridotid wheels with continuous series of teeth on inner rim; single dorsal series of wheel aggregations, a few irregularly scattered wheel clusters dorso-laterally; no wheel aggregations ventrally; chiridotid wheels up to 90 μm diameter; sigmoid hooks scattered in body wall, 232–272 μm long; single polian vesicle; numerous gonad tubules arising from a common hub; single ventral interradial series of ciliated funnels.

Distribution. Eastern Antarctica, MacRobertson Shelf, 109–121 m; Prydz Bay Channel, outfall slope, 795–830 m.

Etymology. Named for Prydz Bay in eastern Antarctica near the type locality.

Remarks. The ossicles in the type specimens show evidence of erosion but are adequate for systematic assessment. The eastern Antarctic *Taeniogyrus prydzi* sp. nov. is distinguished from the western Antarctic *Taeniogyrus antarcticus* Heding by the single polian vesicle and significantly longer sigmoid hooks (see Table 3).

Taeniogyrus purpureus (Lesson, 1830)

Figure 14d; tables 2, 3

Holothuria (Fistularia) purpurea Lesson, 1830: 155–156, pl. 52, fig. 2.—Rowe (in Rowe and Gates), 1995: 268.

Chiridota purpurea.—Jäger, 1833: 16.—Brandt, 1835: 259.—Dujardin and Hupé, 1862: 616.—Semper, 1867: 23.—Théel, 1886a: 35–36.—Lampert 1889: 851.

Chiridota australiana.—Théel, 1886a: 16 (non *Chiridota australiana* Stimpson, 1855).

Chiridota studeri.—Lampert 1889: 849–850, pl. 24 fig. 12.—Ludwig 1891: 359–360 (non *Chiridota studeri* Théel, 1886).

Trochodota purpurea.—Ludwig, 1898: 83–87, pl. 3 figs 43–45.—Perrier, 1905: 76–77.—H. L. Clark, 1908: 123–124.—H. L. Clark, 1921: 166.—Pawson, 1964: 466.—Ekman, 1925: 149–150.—Deichmann, 1947: 349.—Pawson, 1969a: 141.—Pawson, 1969b: 38, map 6.—Rowe, 1976: 203–205, table 1.—Hernandez, 1981: 164, 166, figs 1i, j, 4b, c.—Rowe (in Rowe and Gates), 1995: 268.—Smirnov, 1997: 16.

Material examined. Strait of Magellan, mouth of strait, 64 m, USNM 1004241 (2); Isla Bertrand, Puerto Grande, intertidal, Royal Society 1958 Expedition, USNM E16375 (1, no ossicles remaining).

Diagnosis (Pawson 1964). Tentacles 10, each with 2–6 pairs of digits; wheels 130–180 μm diameter (80–144 μm this work, USNM 1004241), scattered in body wall; sigmoid hooks 120–130 μm long (120–160 μm this work, USNM 1004241), scattered in body wall; tentacle rods average 78 μm long (56–120 μm this work, USNM 1004241), bracket-shaped (rare in this work), with dichotomously branching ends; colour commonly purple.

Type locality. Puerto Soledad (Port Solitude), Falkland Is.

Distribution. South America, Strait of Magellan, 64 m (this work); Falkland Is (type locality).

Remarks. In his key to the species of *Trochodota*, H. L. Clark (1921) implied that *Trochodota purpurea* has discontinuous series of teeth on the inner rim of the wheels. Smirnov (1997) observed continuous series of teeth, and pointed out that Hernandez (1981) illustrated a wheel of *Trochodota purpurea* with continuous teeth. We confirm that observation here (Fig. 14d). Ossicle dimensions are given in Table 3. *Holothuria (Fistularia) purpurea* Lesson, 1830 is fixed in this work (above) as type species of *Trochodota* Ludwig, 1891, but we then judge *Trochodota* to be a junior synonym of *Taeniogyrus* Semper, 1867.

It is established above that *Chiridota studeri* Théel is a junior synonym of *Sigmodota contorta* (Ludwig), and this is listed in that synonymy. Lampert (1889, pp. 849, 850) discussed material from the Strait of Magellan that he referred to *Chiridota studeri* Théel, but his description of 10 tentacles, hooks and wheels not in papillae clearly refers to *Taeniogyrus purpureus* (Lesson), and this reference is listed in the synonym here.

We agree above with Ludwig (1898) that the Théel (1886a) specimens of *Chiridota australiana* Stimpson were *Taeniogyrus purpureus* (Lesson).

Subfamily **Chiridotinae** Östergren, 1898 (sensu Smirnov 1998)

Diagnosis (Smirnov, 1998). Chiridotidae with 12 or 18 tentacles. Body wall ossicles wheels of chiridotid type gathered into papillae, and/or rods. Radial plates of calcareous ring perforated or with deep notch in anterior face for passage of nerves. There are 4–30 polian vesicles.

Genera (Smirnov 1998). *Chiridota* Eschscholtz, 1829; *Paradota* Heding (in Ludwig and Heding), 1935; *Polycheira* H. L. Clark, 1908.

Chiridota Eschscholtz, 1829

Synonymy. See Pawson 1964.

Diagnosis (Pawson 1964). Tentacles 12, digits 3–10 pairs, terminal pair longest; polian vesicles 3–20; ossicles six-spoked wheels collected into papillae with varying numbers of wheels of diverse sizes; small curved rods with enlarged ends may be present; minute miliary granules often present in longitudinal muscles; lacking sigmoid hooks.

Type species. *Chiridota discolor* Eschscholtz, 1829

Type locality. Sitka; Sea of Okhotsk.

Chiridota pisanii Ludwig, 1886

Table 2

Chiridota purpurea.—Théel, 1886: 15, pl. 2 fig. 1 (= *Chiridota pisanii* Ludwig, 1886; non *Holothuria* (*Fistularia*) *purpurea* Lesson, 1830; see Ludwig 1898).

(For complete synonymy see Bohn in Altnöder et al. 2007).

Material examined. S Atlantic Ocean, Burdwood Bank, ICEFISH 2004 stn 1–OT1, 54.22°S 59.84°W, 93 m NMV F106959 (1); ICEFISH 2004 stn 1–OT2, 54.22°S 59.83°W, 93 m NMV F106963 (4); Patagonia, 52°12'S 67°19'W, 95 m, *Discovery Expedition*, *William Scoresby* stn 750, 19 Sept 1931, NHM 2010.110 (1, wheel cluster only); Argentina,

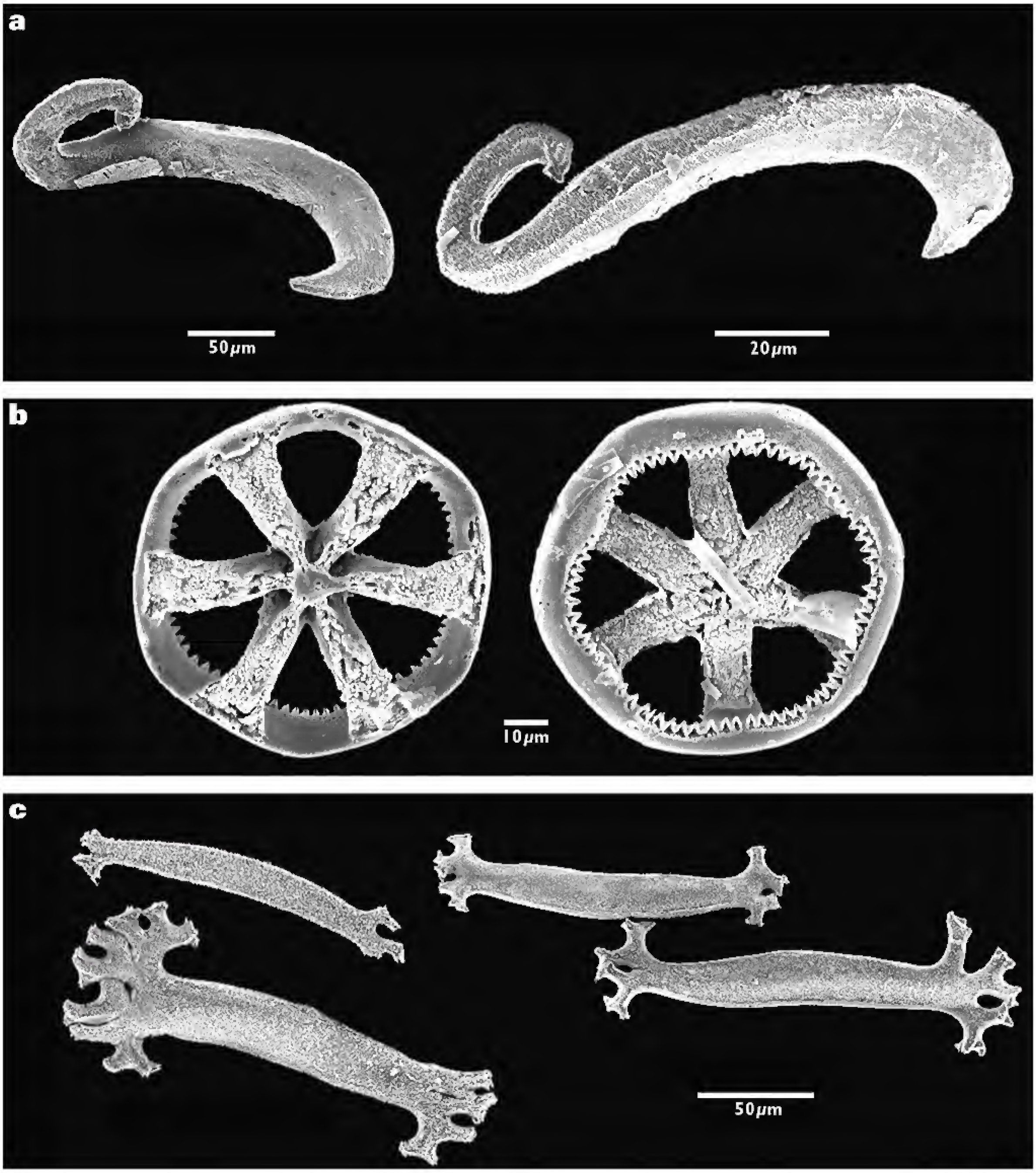

Figure 15. SEM images for holotype of *Taeniogyrus prydzi* sp. nov. (Prydz Bay; NMV F68690). a, hooks from body wall; b, wheels from body wall; c, rods from tentacles.

Tierra del Fuego, 54°00'S 67°24'W, 0 m, 1999, NMV F86016 (2); Cape Horn, 56°20'S 67°10'W, 121 m, *Discovery Expedition*, *William Scoresby* stn 388, 16 Apr 1930, NHM 2010.111 (1).

Diagnosis (from Bohn in Altnöder et al. 2007). Up to 68 mm long (130 mm in Ludwig 1898); tentacles 12, 4–7 pair of digits per tentacle, longest distally, tentacle rods with variably branched ends, sometimes central hub, 16–69 µm long; calcareous ring with 5 radial 7 interradial plates, all radial plates perforated for passage of nerve; polian vesicles 4–11 (–16 in Théel 1886); single ciliated urns at base of mesenteries, numerous in mid-dorsal and left dorsal interradius, sparse in right ventral interradius; chiridotid wheels with serrations on inner side continuous, gathered into papillae in single series in dorsal interradii, inconspicuous or lacking in ventral interradii, 43–147 µm diameter; miliary granules in longitudinal muscles 14–49 µm long.

Colour (preserved). Off-white to pink to reddish-brown.

Distribution. Pacific and Atlantic coasts of southern South America (south of 42°S), Falkland Is, 0–102 m (Bohn in Altnöder et al. 2007); Burdwood Bank, 93 m (this work); Cape Horn, 121 m (this work).

Remarks. Chiridota pisanii Ludwig has not been reported south of the Polar Front, and is not an Antarctic species. Bohn (in Altnöder et al. 2007) has provided a comprehensive systematic treatment with illustrations. He queried the identity of the *Challenger* Falkland Is specimens determined by Théel (1886) as *Chiridota purpurea*, and subsequently judged by Ludwig (1898) to be *Chiridota pisanii*, since the wheel sizes were larger (140–160 µm diameter) than his measurements for *Chiridota pisanii* (43–147 µm diameter). Our ossicle measurements for Burdwood Bank specimens are: wheels 80–144 µm diameter; tentacle rods 48–80 µm long.

O'Loughlin (2002) initially failed to find hook ossicles in specimens from Heard I. and identified them as *Chiridota pisanii*. Hook ossicles were subsequently found, and the material re-determined as *Taeniogyrus contortus* (see O'Loughlin 2009).

Paradota Heding, 1935

Paradota Heding (in Ludwig and Heding), 1935: 150–151, fig. 14.—Gutt, 1990: 125–126.—Massin, 1992: 321–323.—Smirnov, 1998: 520.

Diagnosis. Tentacles 12, peltato-digitate, with 5 to 7 pairs of digits, longest distally; rod ossicles in tentacles; lacking ossicles in the body wall; 1 to 11 polian vesicles.

Type species. Achiridota ingolfi Heding, 1935.

Other species. Paradota weddellensis Gutt, 1990; *Paradota marionensis* Massin, 1992.

Remarks. Heding (in Ludwig and Heding 1935) erected *Paradota* for family Chiridotidae. Gutt (1990) referred *Paradota* to the Synpatidae Burmeister, 1837. Smirnov (1998) judged that the morphology of genus *Paradota* was close to that of genus *Chiridota* and referred *Paradota* to subfamily Chiridotinae.

Paradota weddellensis Gutt, 1990

Figure 16; table 2

Paradota weddellensis Gutt, 1990: 125–126, figs 11–14, table 3.—Massin, 1992: 322–323.—O'Loughlin et al. 2009: table 1.

Material examined. Scotia Sea, South Orkney Is, US AMLR stn 104, 63°13.92'S 59°27.47'W, 759 m, NMV F168842 (5); South Sandwich Is, 351–393 m, USNM E49614 (20+); South Shetland Is, 59 m, USNM E49620 (1).

Antarctic Peninsula, Joinville I., 265 m, USNM E49619 (1); Palmer Archipelago, 126 m, USNM E49616 (1).

Ross Sea, NIWA expedition 2001, 66°49'S 162°37'E, 292 m, NIWA 61095 (1); stn TAN0602/448, 66°56'S 162°57'E, 85 m, NIWA 49800 (1); NZ IPY–CAML stn TAN0802/272, 66°96'S 170°93'E, 658 m, NIWA 38869 (1).

Prydz Bay, ANARE 1987 stn 7, 68°40'S 77°12'E, 505–578 m, NMV F76845 (1); NMV F76846 (1).

Heard I., ANARE AA92–01, 52°57'S 73°21'E, 159–176 m, NMV F84977 (1); AA92–06, 53°13'S 73°40'E, 120 m, NMV F84979 (1); AA92–08, 52°41'S 72°56'E, 215 m, NMV F84978 (1).

Diagnosis (after Gutt 1990). Chiridotinid species up to 180 mm long; body wall thick; tentacles 12, peltato-digitate, 5–7 pairs of digits; calcareous ring lacking anterior and posterior projections; 4 polian vesicles; tentacles with irregular rod ossicles, many slightly bracket-shaped, some with branched ends, some with projections mid-rod; body wall lacking ossicles; longitudinal muscles with rare miliary granules.

Distribution. Circum-antarctic, south of Polar Front, 59–1191 m; Weddell Sea, 225–655 m (Gutt 1990); Scotia Sea, 59–759 m; Antarctic Peninsula, 126–265 m; Bellingshausen Sea, Antarctic Peninsula, Peter I Island, 97–1191 m (O'Loughlin et al. 2009); Ross Sea, 85–658 m; Prydz Bay, 505–578 m; Heard I., 120–215 m.

Remarks. Paradota weddellensis Gutt is a large apodid with a widespread polar distribution south of the Antarctic Convergence. *Paradota marionensis* Massin, 1992 occurs north of the Convergence at Marion and Prince Edward Is (Massin 1992). We found rare miliary granules up to 40 µm long in Ross Sea material.

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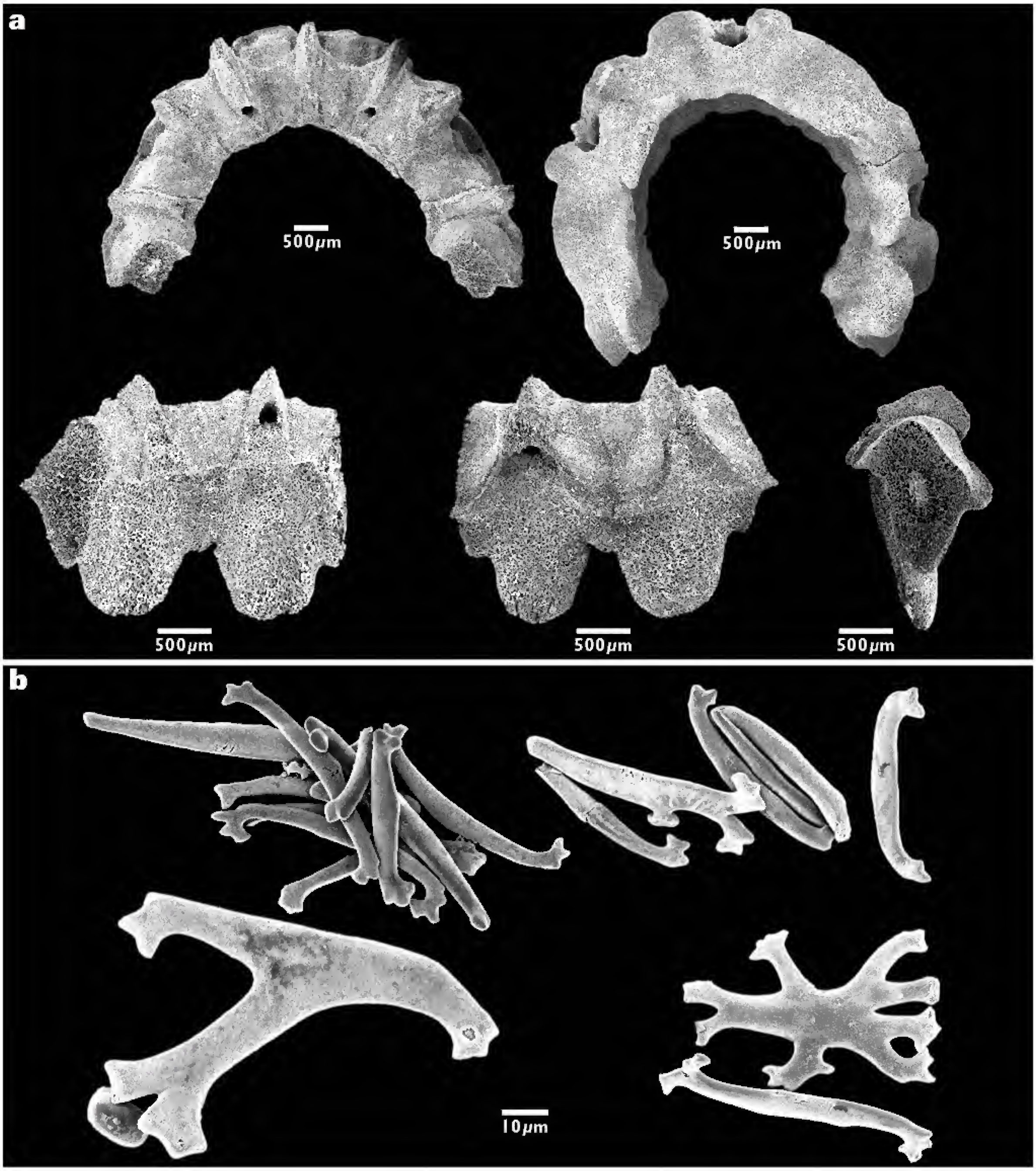

Figure 16. SEM images for specimens of *Paradota weddellensis* Gutt, 1990. a, calcareous ring plates: (from top left) anterior view, posterior view, internal view, external view, section view (South Orkney Is; NMV F168842); b, rods from tentacles (Prydz Bay; NMV F76846).

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